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DEVELOPMENT AND USE OF TRAINING SIMULATORS

HEARINGS

BEFORE THE

SUBCOMMITTEE ON TACTICAL WARFARE

OF THE

COMMITTEE ON ARMED SERVICES UNITED STATES SENATE

NINETY-EIGHTH CONGRESS

SECOND SESSION

SEPTEMBER 26, 27, 1984

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DEVELOPMENT AND USE OF TRAINING SIMULATORS

WEDNESDAY, SEPTEMBER 26, 1984

U.S. SENATE,
SUBCOMMITTEE ON TACTICAL WARFARE,
COMMITTEE ON ARMED SERVICES,
Washington, DC.

The subcommittee met, pursuant to notice, at 8:58 a.m., in SR-253, Russell Senate Office Building, Senator Barry Goldwater (chairman) presiding.

Present: Senators Goldwater and Dixon.

Staff present: Carl M. Smith, James C. Smith III, and John Hamre, professional staff members; Russell C. Miller, research assistant; and Karen A. Love and Inga B. Schoonover, staff assistants.

Also present: Gerald J. Smith, assistant to Senator Goldwater; and Les Brownlee, assistant to Senator Warner.

OPENING STATEMENT BY SENATOR BARRY GOLDWATER, CHAIRMAN

Senator GOLDWATER. I apologize for the fact that we will not have many members of the subcommittee here. We are faced with the last week of the session.

This morning the Tactical Warfare Subcommittee meets to receive testimony from the Office of the Secretary of Defense and from each of the services on flight simulators and simulation technology, and I cannot begin to stress to all of you who are interested in this the importance that I attach to simulation.

I have been engaged in this ever since simulators first came out back in the thirties, and I have watched it grow with great interest, and I cannot think of anything that we are doing that is of more importance than simulators, and frankly, to be honest with you, I cannot think of anything that the Secretary of Defense pays less attention to than simulators, and I think that has to be changed.

It is not only important to our defense efforts, it is important to all of industry. It is almost impossible to think of anything today that cannot be simulated and is simulated.

This is the first of two hearings we will hold this year on the subject of simulators. The second is scheduled for tomorrow, at which time we will hear from representatives from industry and from the leading military laboratory on simulation technology, the human resources laboratory located at Williams Air Force Base.

I have asked each of the service witnesses to focus their testimony on four principal areas: one, a review of major simulator programs addressing cost, schedule, capabilities, and the types of technology employed; two, quantifying the benefits of simulator use in terms of reduced accident rates, increased readiness rates, and improved mission performance; three, new technologies being evaluated for application in future simulators; and four, cooperative development programs for future simulators.

Our purpose in conducting these hearings is twofold. First, we hope to acquire an overview of what each of the services is doing to develop and procure modern, effective training devices, and in this regard, we are looking to establish a benchmark of our current capabilities, and connected with this, as we will hope to discover tomorrow, the innovative efforts of industry and what they are doing, who work with themselves and work with you to produce more and better simulation.

Second, we are interested in learning the direction each of these services is following, and each of the industry representatives, to develop the next generation of simulators. We want to understand which of the advanced simulation techniques offers the greatest promise for future applications.

Underlying these two objectives are several very fundamental concerns which we expect will also be addressed today. These include the funding commitment of each of these services to simulator development, the level of interservice cooperation in simulator research and development, efforts to shorten the development and acquisition cycle, and efforts to reduce costs by avoiding overspecification and inefficient procurement policies.

The committee is pleased to welcome Lt. Gen. Edgar Chavarrie, U.S. Air Force, Deputy Assistant Secretary of Defense for Military Personnel and Force Management, Office of the Assistant Secretary of Defense for Manpower, Installations and Logistics; also, Maj. Gen. Richard Kenyon, U.S. Army, Assistant Deputy Chief of Staff for Research Development and Acquisition; Rear Adm. Richard M. Dunleavy, U.S. Navy, Director, Aviation Manpower and Training Division, Office of Chief of Naval Operations; Maj. Gen. Harold J.M. Williams, U.S. Air Force, Director of Operational Requirements, Deputy Chief of Staff for Research and Development; and Brig. Gen. Alexander K. Davidson, U.S. Air Force, Deputy Director of Plans, Deputy Chief of Staff of Plans and Operations.

Gentlemen, it is a pleasure to have you all with us here this morning, and we are looking forward to your testimony. You can either read your testimony, or submit it for the record. It will be printed in full as if read, and if you do not read it, you can proceed. It is usually a little faster that way. It is all going to be read anyway. I will leave it up to you.

General Chavarrie, you may lead off.

STATEMENT OF LT. GEN. EDGAR A. CHAVARRIE, U.S. AIR FORCE, DEPUTY ASSISTANT SECRETARY OF DEFENSE, MILITARY PERSONNEL AND FORCE MANAGEMENT, OFFICE OF THE ASSISTANT SECRETARY OF DEFENSE FOR MANPOWER, INSTALLATIONS AND LOGISTICS [MI&L]

General CHAVARRIE. Mr. Chairman, thank you.

It is our pleasure and it is certainly a privilege for us to appear before your subcommittee to discuss our policies and programs in defense.

With the subcommittee's permission, I think what we can do, and I think we can all agree that it is better if we just provide the oral statements for the record, and then each service will give a briefing.

I have just a few remarks in general that cut across all the services. I have been in my job a little less than a year now, in Manpower, Installations and Logistics, but I have had, of course, during all of my career an interest in simulators. So I have taken a particular interest since I have gotten into this job to put in the human factor equation into research, development, and hardware.

So, that is my role, and I pledge that I will do that in full cooperation with you certainly, and I think we can get the Secretary's interest up a little bit more, since we now can come at him in two ways, both from the research and engineering side and from the MI&L side.

Senator GOLDWATER. We will come at him from our way, too.

General CHAVARRIE. Yes, sir; we thank you for that. The representatives that are with me will respond, I am sure, on any details that you have on their developments in simulation and training devices. Let me just make about four points, sir, if I may.

No. 1, and these are points that are not new to you, but they are points that I think have to be spelled out from time to time. They certainly do in the Department of Defense, and I think they certainly do in the Office of the Secretary.

One is the effectiveness and efficiency that results from simulation. I think on the effectiveness side it has given us an ability to train much more realistically than was possible in the past. It is, of course, the best medium for teaching and ingraining correct procedures and routine maneuvers such as aircraft cockpit procedures and crew coordination.

I think another important application is that simulation provides us the means for realistic engagements between aircraft and force on force engagements among ground units. These are things that I think we're increasing, and certainly we pledge ourselves to increase it in the future.

On the efficiency side, of course, we can conserve operating funds in certain circumstances. More importantly than thinking about savings, of course, is the increased effectiveness that we get from the funds that you provide us for O&M and for research and procurement and development.

As you know, for example with TOW and Stinger, much of that training is done by simulation. So maximum return for the money that you provide us, I think, is what we mean by point No. 1, efficiency and effectiveness.

Simulation also, mitigates the effect on aircrew proficiency of cuts in flying hours that might have occurred over the last 25 years. This, of course, with your help and the help of the Congress, is being rectified.

I think there has been in the past sometimes undue fear that simulators and flying hours are not correlative, and as you know better than most, they really are. But there is always that latent fear that if you do too much in simulation, it will do something to your flying hour program.

Well, this has proven not to be the case over the past 4 years or so since we have had an increase in our flying hour program. So our intent is to be sure that they are correlative, that we get the maximum amount out of each.

I think the second point I would like to make, sir, is with regard to flying safety, and it is just almost impossible to overstate the contribution that good simulators make to safety, particularly flight safety. As you know, the Air Force and Navy flying safety is better than it has been for a long time. I have some statistics for all of DOD.

In the fifties, class A aircraft accidents for all the services ran at about 20 per 100,000 flying hours. In 1980, the rate is 3.76, and it is 2.76 in 1983, and that is across the services. So there is no question about the role that simulation played in flying safety.

The third point, sir, that we should work on, I think, is an improved development and acquisition process. As you know, the Defense Science Board study in 1982 on training recommended some things to us with regard to simulation.

They had about 17 recommendations to raise the level of consciousness, if you will, with respect to training, and certainly with respect to simulators and simulation and training devices. One recommendation we implemented was to set up an OSD steering committee on training and training techology that is comprised of representatives of the agencies within OSD, and the Office of the Joint Chiefs of Staff. This committee is also tracking implementation of the other recommendations.

And this steering committee is to aid the services. It is not a decree-creating organization. It is to help the services. It focuses advocacy in the Office of the Secretary of Defense for the services with respect to training and to simulation.

So, that was one recommendation which has been implemented. Another recommendation in that DSB study said that we should have a repository or a place where we can analyze training data, and as of August 1 there has been established a training data and analysis center in Orlando, FL, which will report directly to us in the Office of the Secretary of Defense.

It has been done in coordination and cooperation with the services. We especially thank the Department of the Navy for this, because we are down in their territory and also with the Army training device program office. So those are two tangible actions that the Office of the Secretary of Defense has taken with respect to simulators.

So, we think that we are going to do better in improving the development and acquisition process, and particularly the jointness of it, with respect to being more cost effective.

The last point, sir, is staying up with the state of the art, and looking to the future. I think when you see some things that the services are doing with respect to the future, you will be pleased, because I certainly was when I came to this job.

As these training challenges arise, we really do need a forward-looking attitude when it comes to simulators and training devices. We are going to have difficulties with complex systems, so we have just got to all do better. We in the Office of the Secretary of Defense are pledged to do that, in cooperation certainly with you and the subcommittee.

In the short time I have been there I have concluded that we have made substantial progress. I certainly want to thank the subcommittee, and you in particular, sir, for your unwavering support and guidance in this effort, and your staff. Without this support progress would have been much more slow in coming, and certainly much more in a halting way.

So we owe a lot to you. We thank you for that. And I pledge to you that we are going to try to do very much better. Thank you very much.

[The prepared statement of General Chavarrie follows:]

PREPARED STATEMENT OF LT. GEN. EDGAR A. CHAVARRIE, DEPUTY ASSISTANT SECRETARY OF DEFENSE, MILITARY PERSONNEL AND FORCE MANAGEMENT

Mr. Chairman, members of the subcommittee: It is a privilege to appear before the Subcommittee to discuss training simulator policies and programs within the Department of Defense. I am accompanied by representatives from the Army, Navy and Air Force. They are: For the Army, Major General Richard D. Kenyon, Assistant Deputy Chief of Staff for Research, Development and Acquisition. For the Navy, Rear Admiral Richard M. Dunleavy, Director, Aviation Manpower and Training, Office of the Deputy Chief of Naval Operations for Air Warfare. For the Air Force, Major General H. J. (Mack) Williams, Director of Requirements, Office of the Deputy Chief of Staff for Research, Development and Acquisition, and Brigadier General Alexander K. Davidson, Deputy Director of Operations, Office of the Deputy Chief of Staff for Plans and Operations.

The Service representatives can respond to you in detail on developments in simulation within their respective Services. In my remarks, I will set the stage by discussing defense-wide policies and positions on simulation and what is being done within the Office of the Secretary of Defense to promote procedures for development, acquisition and use of training simulators.

POLICY ON SIMULATION

With regard to simulation policy, the Defense Guidance of the Secretary of Defense, published annually, contains general policy guidance for Service training programs, as follows:

Services should establish training requirements that will achieve a level of force readiness commensurate with plans for force employment, and provide those resources needed to satisfy the requirements.

Among the resources which the Secretary expects the Services to apply to satisfy their training requirements are simulators that will improve the effectiveness of training and to help to reach and maintain the required level of force readiness.

Looking back to the record of hearings before this Subcommittee on this same subject in April of 1978, I note that you, Mr. Chairman, expressed the conviction that simulation "should be used to aid in, and improve, the quality of training. Energy savings should be considered as a bonus benefit." This statement is entirely consistent with the Department of Defense view of the value and purpose of simulation. I would like to elaborate a bit on this theme to show the ways that simulation improves the quality of training and, in certain circumstances, provides us bonus benefits in savings.

BENEFITS OF SIMULATION

Training available only through simulation.—The first great benefit of simulation to good training has been the enhanced ability to practice combat and other operational activities that cannot be adequately practiced in any other way. As you know, flight safety is a priority objective in the Department. Flight simulators give both student pilots and experienced pilots the ability to practice recoveries from in-flight emergencies that it would be foolhardy to induce in actual flight. This capability is of great importance in developing and maintaining proficiency in dealing with emergency situations and preserving the lives of aviators.

Equally and perhaps more important is the realism that various forms of simulation have brought to opposing forces training. The historical demarcation between training and combat has always been the unrealism in training caused by the fact that training targets can't shoot back or maneuver intelligently. A few of the most advanced and expensive ground-based flight simulators overcome this unrealism by allowing pilots to maneuver against each other. A more widespread and growing way of achieving this objective is instumented air combat maneuvering ranges, called ACMI by the Air Force and TACTS by the Navy and Marine Corps. For land-force training, the MILES laser engagement system has turned force-on-force maneuvers from generally inconclusive melees into conclusive engagements in which the effect of fire is immediately known and object lessons can be learned and absorbed.

A final aspect of this benefit of simulation is that it helps to compensate for constraints in ground and air space for training. Training space, which is mainly an inheritance from the World War II build-up, ranges, with a few exceptions, from inadequate to marginally adequate. Simulation provides the means to take maximum training advantage of the space that is available. It also makes possible at least some useful substitute training for military units which cannot be accommodated within the capacity of existing training space. This attribute of simulation is particularly important for Reserve Component units, whose training activities are constrained by limited time as well as space.

Supplement to training on primary equipment.—The second great benefit of simulation has been in supplementing training on primary equipment, such as aircraft or tanks. The venerable Link Trainer led off this use of simulation a half-century ago. Simulation is not an indispensable part of every type of undergraduate flight training in every Service and is an important contributor to high-quality transition and continuation training for virtually every aircraft in the inventory. Simulator use with ground weapons and ship systems is on the way to becoming as prevalent as it is in use with aircraft. The most useful feature of simulation in the role of supplementary training may be its ability to support repetitive practice of routine maneuvers and actions, such as take-offs and landings or tank gunnery procedures. This use of simulation allows operators and maintainers to be trained quickly and effectively, and makes it possible for instructors to identify bad practices and correct them without loss of time.

Compensation for high cost of training.—As the Subcommittee has said, we should place first priority in simulation on raising the quality of training and consider cost savings from reduced use of primary equipment as a bonus. But let's put this general rule in perspective. Training costs on some systems have not simply increased, they have rocketed upward. Take, for example, the shoulder-fired Stinger air defense weapon. The Stinger will be manned by a large number of two-man teams made up of young soldiers and Marines, most of them in grades E–2 to E–4. These teams will not be able to use their weapons effectively unless they are well trained. On the other hand, a single Stinger missile costs about $75,000. In addition, actually firing a "fire-and-forget" heat-seeking missile contributes somewhat less to gunner proficiency than firing a type of missile that must be guided into the target. It is unreasonable to think that we are going to fire many Stingers for training if there is any reasonably effective alternative. In fact, the Army and Marine Corps are relying almost exclusively on simulators for Stinger training. In this case, at least, the savings bonus becomes the controlling factor in deciding whether to use simulators as the primary equipment for training.

Something similar has happened with regard to flying hours. Twenty or thirty years ago, flying hours were cheap, at least by today's standards, and pilots routinely flew 30 or 40 hours a month. The amount of flying has come down substantially. I think that it is logical to assume that flying hours would have been reduced, although probably not by so much, even if no simulators existed. The increase in the cost of flying would have squeezed out all of the fat and some lean as well. In any case, the flying hours now available for training are no more than adequate. This

level of activity is acceptable only because simulation has increased the training value of the hours flown and has compensated, to some extent, for the loss of hours that simply would not have been funded for budgetary reasons.

In addition to cushioning the effects of increased training costs, simulation does save directly on training expenses in some cases. Use of simulation may speed up the training process and thus save on manpower and support costs. The availability of simulators may make it possible to buy fewer major systems to devote exclusively to training. In training of TOW missile crewmen, simulation is the principal teaching vehicle; considering the number of people that must be trained and kept proficient, very few missiles are fired in training. Finally, simulation has explicitly been used to reduce the number of flying hours in several undergraduate flight training programs.

I believe that it is correct to say that the services, in using and planning simulators, are alert to take advantage of the cost saving bonus while giving the proper priority to improving the quality of training.

LIMITS OF SIMULATION

Simulation, despite its value, is subject to limitations. In a sense, training through simulation relates to training with primary equipment in the same way that training of any type relates to combat. Just as good training may be quite similar to combat, training on a good simulator may be much like training on the real equipment. But, in both cases, there are very real and significant differences.

Imperfect replication.—In the first place, simulation seldom achieves perfect replication of the simulated equipment and the simulated environment. Attempting to achieve perfect replication may drive simulator costs through the roof without producing a commensurate training payoff. Furthermore, simulation cannot replicate an operator's feelings in dangerous maneuvers, such as night landings on a carrier deck. There is no prospect of ever fully replicating combat conditions in air-to-air or other force-on-force engagements. Finally, if the principal equipment is used very little or not at all in training, there is likely to be some degrading of operator confidence in the weapon that could affect combat performance.

Lack of total system checkout.—One of the advantages of conventional training on actual equipment is that it allows a checkout of the operator, the equipment and any associated weapons as an integrated system. The periodic firing of air-to-air or surface-to-air missiles at target drones provides such a checkout, with total system training either as the principal object or as a bonus to a testing process. Simulation does not provide conclusive test results with associated training benefits.

We have learned how to expand these limits or, as necessary, to accommodate to them. We must be alert, however, to resist those who would ignore the limits purely for the sake of decreasing training costs. To protect the integrity of training, we must continue to have the support of the Congress and, in particular, of this Subcommittee, which has been the primary legislative supporter of the rational use of simulation.

ACTIONS TO ENHANCE SIMULATION AND TRAINING

I will now turn from policies and concepts to some of the actions we have been taking to improve military training and our use of emerging training technologies, to include simulation.

Defense Science Board recommendations.—Two years ago, a panel of the Defense Science Board studied the state of training and training technology within the Department and made recommendations to correct identified deficiencies.

One of these deficiencies was a lack of concerted action and leadership within the Office of the Secretary of Defense to improve training. As a result, Secretary Weinberger established an OSD Steering Committee on Training and Training Technology to fill this gap. I am the current chairman, and senior representatives of the Offices of the Joint Chiefs of Staff, Under Secretary for Research and Engineering, Comptroller, Assistant Secretary for Reserve Affairs and Director of Program Analysis and Evaluation are members. Our intent is to assure that needed improvements in training are recognized and achieved and that opportunities to take advantage of advances in training technology receive priority management attention.

Another void identified by the Defense Science Board was the lack of a central capacity for gathering, organizing, and analyzing data and information on training. The Defense Training Data and Analysis Center, or TDAC, is now operational in Orlando, Florida, and is preparing to provide DOD-wide services to help in improving training of all types. This Subcommittee will be particularly interested in two of the staff divisions of TDAC, one for simulation and the other for training ranges.

As a related organizational matter, I recently created a separate Training Policy Directorate within my own office. My objective is to improve our capacity to formulate and recommend needed training policies and to provide more thorough review of training programs and budgets.

In compliance with another key Defense Science Board recommendation, funding for research in training is being substantially increased. In fiscal year 1984, $110 million was appropriated for research on simulation and training devices within the general area of Training and Personnel Systems Technology. For fiscal year 1986, we anticipate that the budget request will be for about $220 million. To achieve this objective, however, we will need powerful assistance from those in the Congress who understand the need. Part of the reason for the size of the dollar increase, as you would suspect, is congressional reductions to last year's budget request. We have not been as successful as we should be in persuading the Congress as a whole that training research has a potentially high payoff in future readiness and deserves full support.

Guidelines for simulator acquisition.—The House Appropriations Committee has directed us to prepare guidelines for the orderly development and acquisition of simulators and other training devices. We are now completing these guidelines, and they should be approved shortly. The guidelines will stress integration of training considerations into the development process from its inception, methodical examination of the effectiveness and cost of alternative training concepts and equipment, planning for training systems evaluation, systematic review of programs by the Office of the Secretary of Defense at specified points, and full funding of validated training requirements. Our intent is to use these guidelines to avoid some of the problems that have occurred with training developments in the past, particularly those cases in which training equipment was provided late or even not provided at all.

CONCLUSION

In conclusion, I hope that my remarks have helped to clarify the Department's views on the benefits we are deriving, and intend to derive, from simulation. I also hope that I have properly conveyed the dedication of the Office of the Secretary of Defense to the cause of better training.

Senator GOLDWATER. Thank you very much, General.

Who is next in line?

General CHAVARRIE. I think we will go Army, Navy, and Air Force. So the Army is next.

Senator GOLDWATER. Yes, we have to take care of them, you know. OK, General.

STATEMENT OF MAJ. GEN. RICHARD D. KENYON, U.S. ARMY, ASSISTANT DEPUTY CHIEF OF STAFF FOR RESEARCH, DEVELOPMENT, AND ACQUISITION, DEPARTMENT OF THE ARMY

General KENYON. Thank you, sir.

It is a pleasure to be here this morning, and although some folks do not think much about Army and aviation and our activities in that area, as you know, we operate a fleet of about 8,500 helicopters. So flight simulation is very important to us.

But in addition to that, we have used the background of aviation simulation to get to simulation training for our tactical vehicles and our individual soldiers.

TRAINING DEVICES AND SIMULATORS

Realistic training simulation now possible; conserve resources, safety/environmental benefits; more training capabilities/opportunities; enormous scope: flight simulators; institutional trainers; combined arms engagement trainers; and threat simulators.

[In millions of dollars]

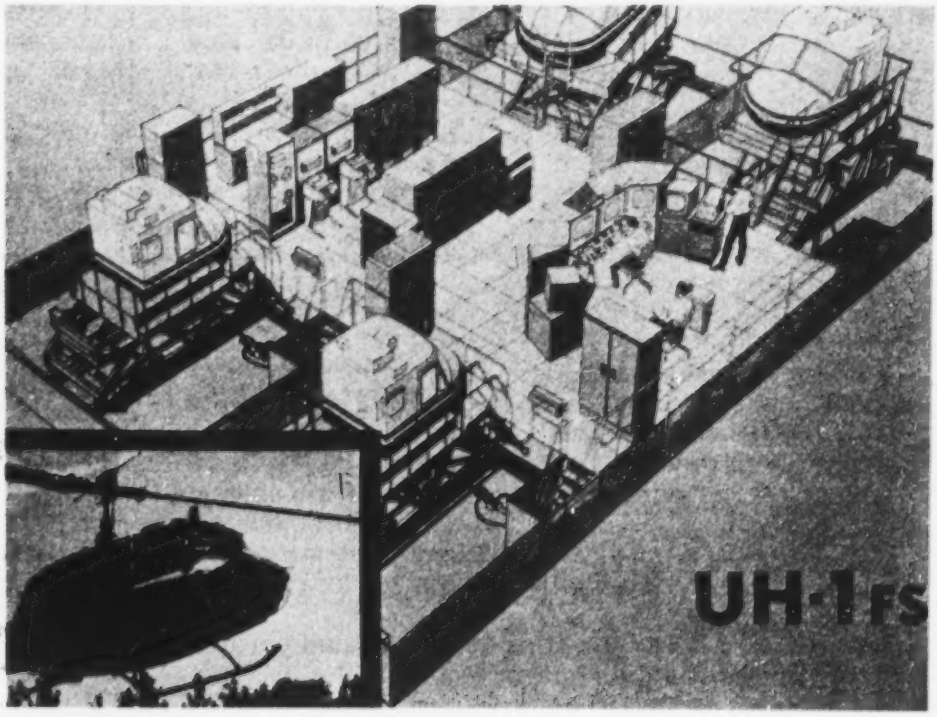
	Fiscal year—			
	1982	1983	1984	1985
RDT&E	52.9	60.5	75.9	121.4
PROC	134.3	399.4	436.8	553.2

We look at many aspects. Of course, as we get into simulation, one of the first things we look for in the area of safety is in the helicopter simulation and flight simulators.

More and more we have to look at the environmental aspects, because the modern systems like the M-1 tank use laser systems designated for the Hellfire missile, and we have to watch our ranges and the impacts there.

Also in the area of capabilities and opportunities you know well that the opportunities to train our ground troops are quite limited, that we have a small number of training areas, and some of them are not too large, so that we have gone into a whole series of simulators now.

We have given it emphasis programmatically as shown by this bottom line showing the growth in both the RDT&E and procurement in our program.



Let me start first then on a system orientation with the UH–1, of which we operate some 3,500 aircraft of this type today, and we will have them for a significant period of time.

We have a simulator, which is the first one that we procured in about the mid-1970's. And it is a device that does not have a visual display for the pilot, but there are four cockpits in each of the sets that we have of our 22 in which the pilot can be trained in procedures, both the procedures of the aircraft and the flying procedures, for instance, in instruments.

As an example, a few years ago, at Fort Rucker, where we do our initial pilot training, an aviator got 60 hours of flight training and 26 hours in the simulator to get through the instrument course. We have looked at that and worked it, and getting to know more about the simulator. He now flies only 20 flight hours and gets 40 hours of simulation. So, we have saved a great deal of money there, and improved the safety aspect.

Senator GOLDWATER. Let me ask you a question about that. I flew that simulator, and being a helicopter pilot, I was under the impression after just maybe an hour that you could give a young man time in that simulator, and send him up with an IP, and he could probably handle the helicopter.

Do you find that true?

General KENYON. Yes, sir, very much, so that once—if you have an individual who starts in the TH–55 helicopter and gets the feel of the helicopter that you know you have to get, using both hands and both feet, and you can put him in that simulator, he can go right to the UH–1 very quickly.

Senator GOLDWATER. I was thinking about putting the man in the simulator before he had ever gotten into the helicopter, and then moving him over. Do you do it that way, or do you give him the feel first?

General KENYON. We give him the feel first today, sir.

Senator GOLDWATER. Could you do it the other way?

General KENYON. I do not know that we have tried that, sir, but we could look at that.

Senator GOLDWATER. I mean, it is interesting. The simulation is so good. I thought maybe he could go that way into the bird and have a better feeling than into the bird and then back into this. But that is up to you.

General KENYON. Let me correct myself, sir, and say that when a student finishes the small Hughes TH–55 before he goes into the UH–1, he gets a considerable amount of simulator time. I can't recall the exact number of hours, but he does get that initial feel in the TH–55.

I will look into our exploration of that and get back to the members of your staff on it, though, too.

Senator GOLDWATER. Thank you.

General KENYON. In this case, we have got 22 of these devices in service today.

UH–1 FLIGHT SIMULATOR BASIS OF ISSUE PLAN

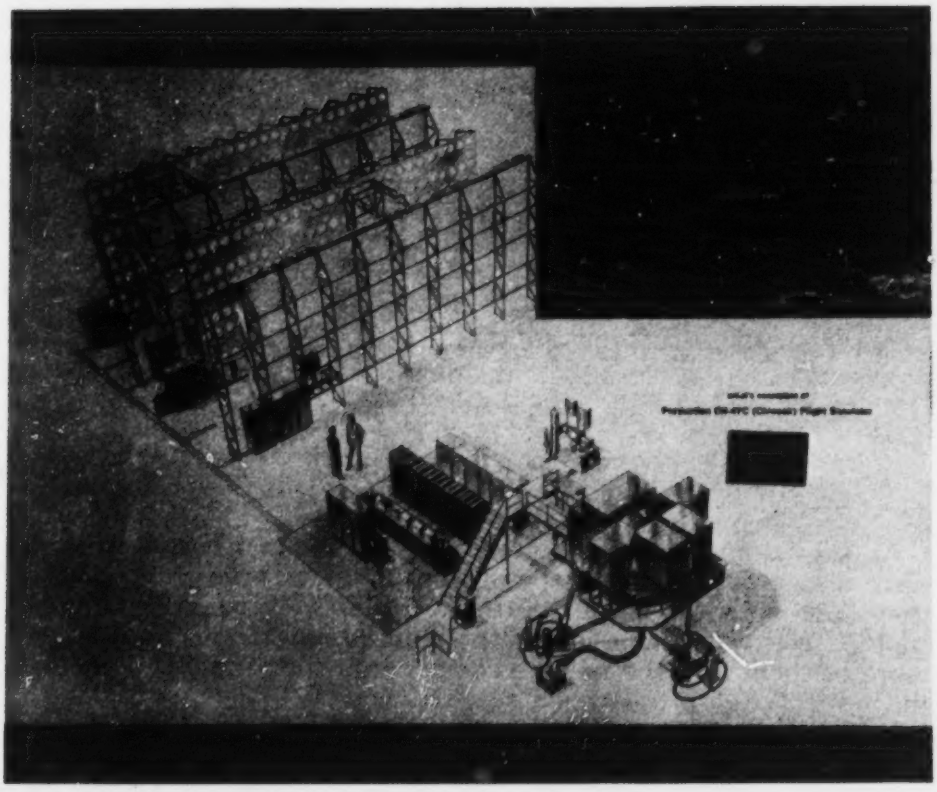
Unit	Location	Ready for training
Prototype	Fort Rucker, AL	In use.
Production units:		
1–7	Fort Rucker, AL	Do.
8	Fort Hood, TX	Do.
9	Fort Campbell, KY	Do.
10	Fort Lewis, WA	Do.
11	Fort Bragg, NC	Do.
12	USAREUR	Do.
13	Hawaii	Do.
14	National Guard	Do.
15	Korea	Do.
16	Fort Stewart, GA	Do.
17	Fort Riley, KS	Do.
18	Fort Knox, KY	Do.
19	Fort Ord, CA	Do.
20	Fort Sill, OK	Do.
21	Fort Belvoir, VA	Do.

As shown on this chart in the locations you will note that we have also provided at this point one to the reserve component so they have access to it all the time. And as we modernize our helicopter fleet, we will maintain the simulators and move more and more of them into the reserve components with the UH–1 helicopter.

In the case of these, they average about 225,000 operating hours per year, which when you compare that to the operating cost of the helicopter itself, and the difference, it is a difference of about $96 million a year today, which is a pretty good figure considering that the acquisition cost of these in the mid-seventies was about $59.9 million.

Senator GOLDWATER. How much per unit? Do you remember?

General KENYON. About $2 million per copy, sir.



The next simulator, which is well along in fielding, is for the CH–47 Chinook, our medium-lift aircraft system, which is not armed, but is a cargo and utility aircraft.

Here is a pictorial of the flight simulator for it, where the cockpit is shown with the operator boards here, and then in the back the displays that you have seen before of the mapped terrain, and how the camera now picks off the information and feeds it into, in this case, our first visual display in the simulator.

CH–47 CHINOOK FLIGHT SIMULATOR

FUNDING PROFILE

[Dollars in millions]

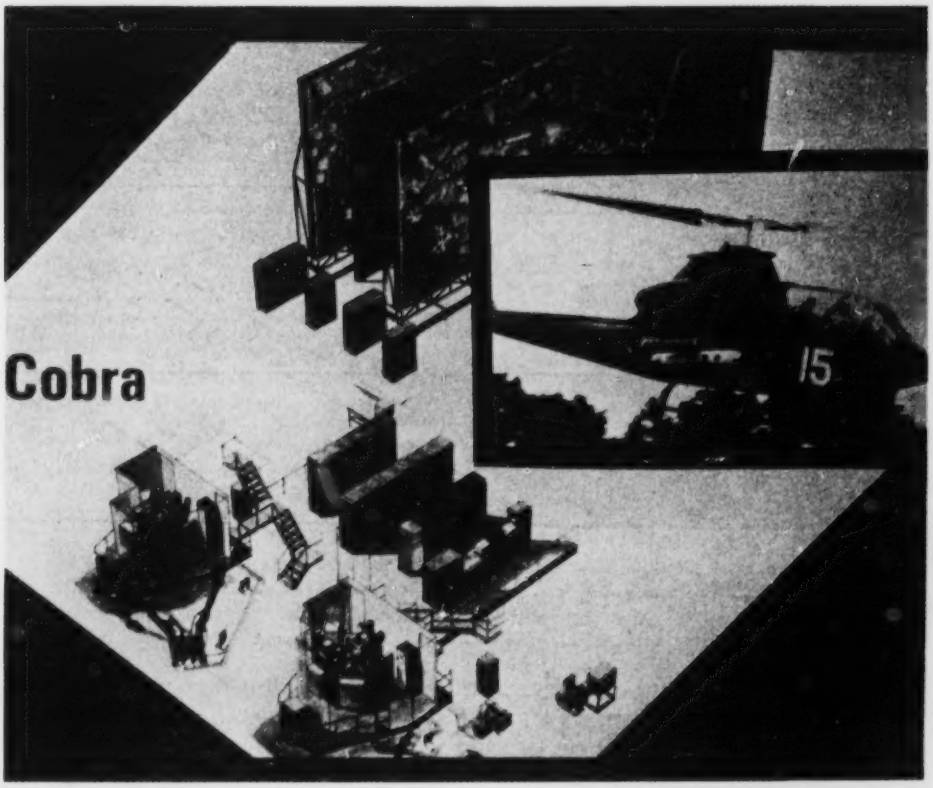
	Quantity	Amount
Fiscal year:		
1983 and prior	5	$48.0
1984	1	22.2
1985		6.0
1986 (estimate)		

BASIS OF ISSUE PLAN

Unit	Location	Ready for training
Prototype	Fort Rucker, AL	In use.
Production:		
1	Fort Campbell, KY	Do.
2	Fort Hood, TX	Do.
3	Mannheim, Germany	Do.
4	Fort Lewis, WA	April 1986.
5	Korea	July 1988.

We have currently in the program procured the six that we required. However, the initial four that we procured were in the C model configuration, and we are upgrading those to the most recent delta model configuration.

Four are in use today, and we got about 2,000 hours per simulator in these, and then you can see that we also have one in Germany and later go to Korea with this one also. These simulators support a fleet of about 500 Chinook aircraft.



The first armed system is the Cobra. The AH-1 Cobra, of which we have approximately 1,000 basic armament systems, carries the antitank TOW, and also 20-millimeter and 2.75 rockets, and we can train on all of those weapons systems plus the flight procedures. In

the simulator layout we have two cockpits, one for the pilot and one for the gunner.

And they can be programmed and utilized so that you could have a separate pilot mission and gunner mission, or you could tie the two together for the crew coordination that is necessary in the execution of fire missions.

You can see the boards. The information for the visual is much smaller and compact, and that is because here we are able to transition into the computer-generated imagery which is more realistic and is getting to the point today, Senator Goldwater, where we can actually even train in the tactics of flying nap-of-the-earth.

Before the fidelity of computer-generated imagery was such that the pilot did not have the proper depth perception and the vision that he needed to estimate distances, but now we are getting to that point.

AH–1 FLIGHT AND WEAPONS SIMULATOR

FUNDING PROFILE

[Dollars in millions]

	Quantity	Amount
Fiscal year:		
1983 and prior	6	$104.5
1984	1	23.1
1985	2	34.8
1986 (estimate)		

BASIS OF ISSUE PLAN

Unit	Location	Ready for training
Prototype	Fort Rucker, AL	In use.
Production:		
1	Fort Hood, TX	Do.
2	Hanau, Germany	Do.
	Fort Rucker Retrofit	December 1984.
3	Fort Campbell, KY	January 1985.
4	Illesheim, Germany	April 1985.
5	Fort Lewis, WA	July 1985.
6	Fort Rucker, AL	August 1987.
7	Fort Indiantown Gap, PA	November 1987.
8	Marana, AZ	February 1988.

In this system, our requirement is for nine. The last procurement is in our 1985 program. You can see where they are currently in use and where they will be fielded in the future.

In this system, as in all the systems, we do a complete analysis based upon density of aircraft, geographical dispersion, and aviators to determine where and how to put these simulators to get the maximum utilization out of them.

Senator GOLDWATER. Let me ask just one question about that. In the Army, in particularly your helicopter flying, do you have occasion to give what we call in the Air Force line checks?

Do you feel at times it is necessary to check a pilot and copilot in their proficiency, and can you do it with a simulator as well as you can do it with the bird?

General KENYON. We do that, yes, sir. Each aviator has at least one annual check with the standardization instructor pilot in order to check his proficiency as he progresses through the annual training cycle.

We find that for instance in the UH–1, in the simulator you flew, we can give almost that entire check in a simulator.

We are finding today now that we can give almost that entire check in the armed helicopters in a simulator, because we now can simulate all of the weapons to include the tracer round moving out in the visual display, the impact, and then there is a real time interchange.

The only difference, Senator Goldwater, is the autorotation, the engine out emergency, where you have got the landing in the field. That is about the only thing that we require the actual aircraft to do.

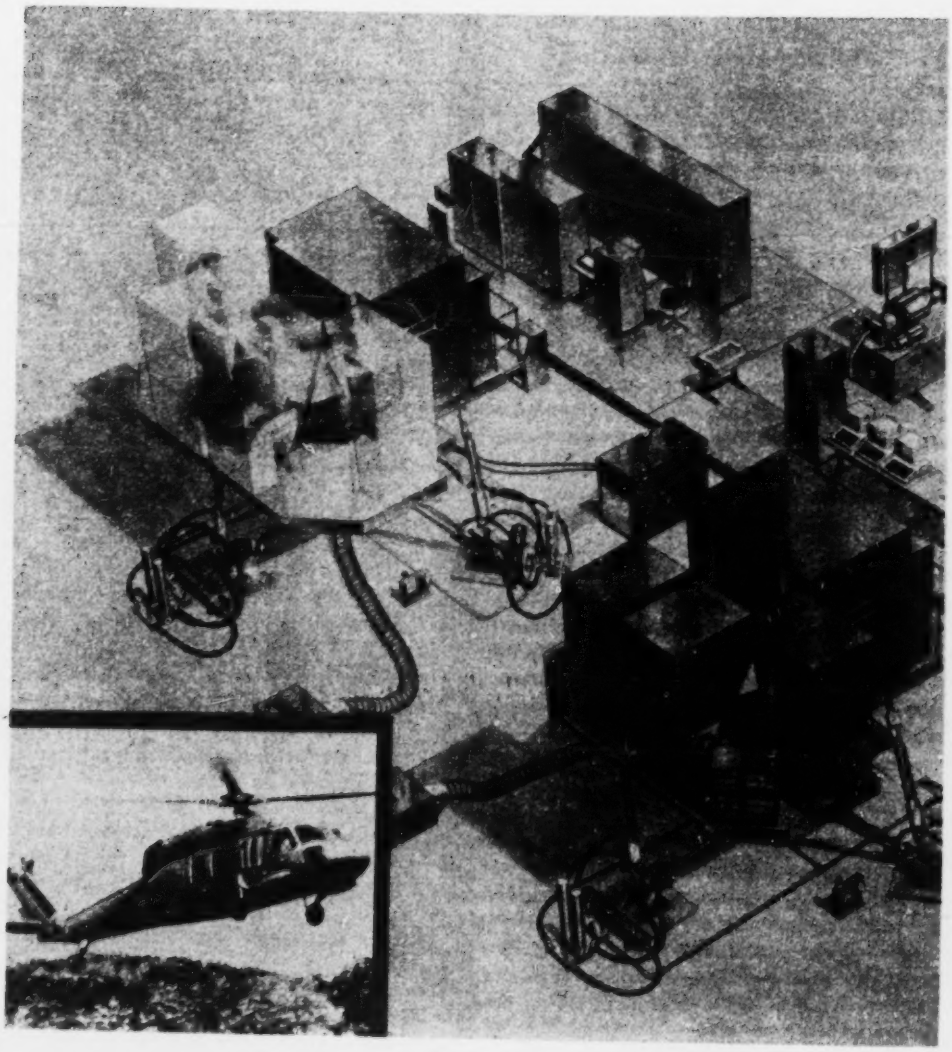
Senator GOLDWATER. I asked that question because you seem to have spread these simulators quite across the world, and I wonder what you should have for one, say, oh, at Hanau, Germany, if it were not for check purposes. By the time a man gets there, he is a qualified helicopter pilot. You do not train overseas, do you?

General KENYON. We do not train initial aviators. No, sir. But we will take the man, in this case a Cobra aviator who is assigned to the Third Armor Division stationed at Hanau, Germany, and he is required to fly so many hours per year to maintain his training proficiency.

He is today required to get 20 hours a year minimum in the simulator for procedural and armament training.

Senator GOLDWATER. All right. That answers my question. Thank you.

General KENYON. The next is related to the UH–60 Black Hawk, which is displacing selectively the UH–1 helicopters in our utility fleet.



Here is a layout of the simulator for the Black Hawk, where we have the control stations and the aviator's cockpit, and again a computer-generated imagery device.

UH-60 BLACK HAWK FLIGHT SIMULATOR

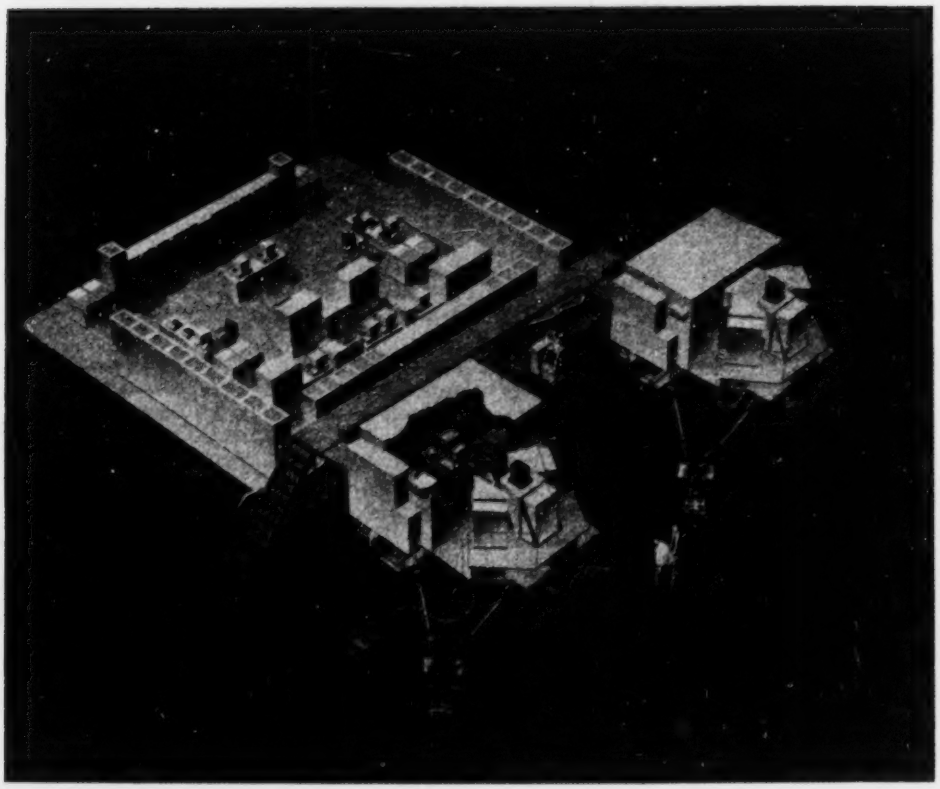
BASIS OF ISSUE PLAN

Unit	Location	Ready for training
Prototype	Fort Rucker, AL	In use.
Production:		
1	Hanau, Germany	March 1987.
2	Illesheim, Germany	June 1987.
3	Fort Campbell, KY	September 1987.
4	Fort Campbell, KY	November 1987.
5	Fort Lewis, WA	March 1988.
6	Fort Bragg, NC	July 1988.
7	Fort Hood, TX	November 1988.
8	Korea	January 1989.
9	Alaska	March 1989.
10	Fort Ord, CA	May 1989.
11	Korea	July 1989.
12	Fort Riley, KS	September 1989.
13	Fort Carson, CO	November 1989.
14	Fort Stewart, GA	January 1990.
15	Fort Polk, LA	March 1990.

This one has not started fielding yet. There is a prototype located at Fort Rucker, and I will say that perhaps we learned some lessons from this one in that when I was the program manager on the Black Hawk, we did not have a concurrent program to field the simulator with the aircraft.

We are trying to do that now with the next system, the Apache, but you can see that we have some 550 Black Hawks out in the fleet today, and we do not have a trainer in the field other than at Fort Rucker, AL. So, we lagged in the fielding, and this is one of the lessons we have learned, and an improvement that we are making.

You can see here the distribution of the Black Hawk simulators as related to the distribution of the aircraft also.



The procurement is shown here starting—the total requirement is for 16 systems throughout the world, and we finished our program procurement in fiscal year 1988.

UH-60 BLACK HAWK FLIGHT SIMULATOR

FUNDING PROFILE

[Dollars in millions]

	Quantity	Amount
Fiscal year:		
1983 and prior	1	$11.1
1984	3	42.9
1985	3	53.8
1986 (estimate)	4	70.7

The last aircraft simulator is for the Apache, which I know you are totally familiar with, and it really brings out some of the benefits of simulation more so than we have ever seen before.

For instance, the Hellfire missile with laser designation, the environmental impacts unit cost of about $45,000, but with the simulators again, with a gunner-pilot configuration, computer-generated imagery, we can train all aspects of that aircraft system again

other than the autorotation, which we do not do much of today, but some of it that we do we have to do in the actual aircraft system.

We also are looking at how many Hellfires we would fire for training. We feel that that would be almost zero, but we also feel just to check out this complex system perhaps once a year, just the same as you brought out, that we check the aviator, that we may fire one missile per year off of each aircraft to check the working of that whole system.

AH-64 COMBAT MISSION SIMULATOR

FUNDING PROFILE

[Dollars in millions]

	Quantity	Amount
Fiscal year:		
1983 and prior	1	$36.0
1984		41.6
1985	3	63.4
1984 (estimate)	3	70.0

BASIS OF ISSUE PLAN

Unit	Location	Ready for training
Prototype	Fort Rucker, AL	August 1985.
Production units:		
1	Fort Hood, TX	August 1986.
2	Illesheim, Germany	November 1986.
3	Fort Campbell, KY	September 1987
4	Fort Bragg, NC	December 1987.
5	Weisbaden, Germany	July 1988.
6	Hanau, Germany	November 1988.

The requirement is for seven simulators, and you can see that the first one will be fielded at Fort Rucker, AL, the training base, almost concurrent with the start of aviator training, in that in 1985, calendar 1985 we start the fielding of the Apache helicopter with these fieldings correlated to the fielding of the aircraft system.

With all of that, and the advent of the M-1 Abrams tank laser designators and a complex crew environment, we have transfused a great deal of that aviation expertise into training for the armor systems.

Called a conduct of fire trainer, it will be in basically three configurations. Each battalion that gets either the M-60A3 tank, the M-1, the M-1A1 upgrade to the 120-millimeter gun, or the Bradley infantry or cavalry fighting vehicle will have one unit set of training which is composed of basically five modules, four of which have about 85 percent commonality for cost savings both in acquisition and maintenance.

The primary difference is in the gunner station in each of these simulators which is a reproduction of his vehicle. He can do a great deal of his gunnery training right in this simulator.

In addition, you can also do procedural training. You will note that there is a visual display. This is a depiction of the gunner's view, which shows a helicopter and another tank.

We can use it for target identification. We can degrade the environment so it is like Europe in fog or haze, and we can simulate the blast and noise effects so that he is very close to the actual firings.

We have not made a final position yet but, for instance, for a tank we feel that with this device we can cut the annual crew ground expenditure from the current 134 by 34 rounds per year, down to about 100.

If we do that, that will save somewhere between $5,000 and $22,000 a year on ammunition per crew or vehicle, about $6,000 wear and tear on that vehicle, and if we do that, the cost of these will be amortized within about a 3-year period.

We step up one beyond that in each battalion, and at the training base we link four of these together to have a major system, training system in each of our training base locations.

And in order to efficiently accommodate the reserve component requirements, we will take one of the unit configurations and put it in a van so it is mobile, and be available to the reserve components that have those same vehicles.

Now, the reserve component outfits that are what we call round out and go to war with our early deploying will have these units set on site.

CONDUCT OF FIRE TRAINER [COFT]

FUNDING PROFILE

[Dollars in millions]

	Quantity	Amount
Fiscal year:		
1983 and prior	50	$167.6
1984	53	111.0
1985	57	112.3
1986 (estimate)	77	150.2

BASIS OF ISSUE PLAN

Location	M1 series [1]	M60 series	M2/M3 series
USAREUR	33	8	37
FORSCOM	27	8	31
TRADOC	32	3	56
8th Army		2	

The procurement has been started. We finish that procurement in 1986 of approximately 240 units. The first unit is to be fielded in the United States. There are four of them actually coming off the line in November of this year, and then they will be coming out regularly after that in all of the configurations, and you can see that we cover our major commands and our traning base with those devices.

So, here is one that we are really excited about, the training benefits, the safety, the procedures, the readiness of our troops, because we have a tremendous turnover of troops in these crews, we can give them the training right in here without having to wait until they go to a major training area and get on their equipment.

Another system which helps us a great deal in the sense of infantry and mechanized forces, in understanding and training as close to combat as they can is the MILES system employed by the Army today and also by the Marine Corps, where we have a small laser emitting device and a small laser receiving device.

You cannot see it on the tank as well, but in force on force training, we can now tell what targets are killed, and what soldiers are killed. We have seen significant benefits in where we are now with the soldiers' individual weapons training, the TOW, the Dragon, the Bradley, the Abrams devices are coming out shortly.

We are getting almost our entire force outfitted with this, and the laser is so low energy we really do not have any environmental impacts. We currently have it on some of our helicopters. We are expanding it to get all of the helicopters.

The Sergeant York air defense system, a simulation of artillery where a device will fire a simulated round which has a small bursting charge that gives off energy detected by these soldiers, can be imposed with our artillery fire when they are training. You can see the other applications here.

This has done a great deal for us as we have gone along in training.

TRAINING SIMULATION—THE FUTURE

ADA.
Microprocessors.
Modular design.

And I will show some of the benefits near the end of my briefing. The future holds even more advantages, although we think the breakthrough of high fidelity computer-generated imagery has given us a great deal today.

Three areas that we are looking at are a common computer language amongst the services, so we have the commonality of sofeware, microprocessors, and here, like we did in the conduct of fire trainers, a modular design which gives us again greater commonality and more ease of maintenance.

TACTICAL ENGAGEMENT SIMULATION

Key to Army's conventional fighting capability is proficiency of squads and platoons.

Two-sided force-on-force training thru tactical engagement simulation provides following improvements over conventional training:

Mission	*Percent improvement*
Detecting targets	55
Engaging at greater ranges	163
Destroying more enemy weapons systems	26
Suffering fewer casualties	49

Here is a little bit on the MILES system and what we found in low level units today, say, at the squad level, as we analyze the training that was going on with our soldiers prior to this system,

and as we look it it now. These studies are done by behavioral scientists at our ARI, the Army Research Institute.

We find these kinds of data and improvements in the conduct of those small unit operations. One of the big things we are looking at is to get this up to, say the platoon or the company level so that we can get the benefits in even larger units.

1 UH-1 FLIGHT SIMULATOR

14,300 available training hours.
22 UH-1 training equivalent.
1,287,000 gallons of fuel saved.

The UH-1 simulator, I show here to highlight the fact that with 4 cockpits, there are that many training hours available in each one of those 22 devices, and over a period of a year equivalent to that amount of savings of gasoline, although I agree that that is secondary. The first is the improvement of safety and readiness in aviation units which we get through use of these simulators.

With that, sir, I think that we have moved out in the Army. We are looking at all of our aviation systems moving across to the ground systems and the individual soldier. I think that we are seeing the dividends of this simulation every day now, and we are right on the verge of having it throughout the Army.

[The prepared statement of General Kenyon follows:]

PREPARED STATEMENT BY MAJ. GEN. RICHARD D. KENYON, OFFICE OF THE DEPUTY CHIEF OF STAFF FOR RESEARCH, DEVELOPMENT AND ACQUISITION, DEPARTMENT OF THE ARMY

Mr. Chairman and members of the committee, I appreciate for opportunity to make a statement in support of the Army's development and use of training simulators. The Army strongly feels that this is a very important facet of our overall program to sustain and to further combat readiness.

To insure that I address your areas of principal interest, I have structured my statement to correspond with the outline submitted by the subcommittee. That is, I will first present our current programs, then the Army's use and application of simulators, followed by our direction with simulator technology and finally, interservice cooperation.

The flight simulator program was conceived in the late 1960's, developed and fielded in the early 1970's and utilized as a means of reducing the number of aircraft required to support aviator training during the Vietnam conflict. In practice, these simulators have also greatly improved efficiency of training due to especially designed automated training features and because of their immunity to weather conditions and maintenance problems that might inflict training delays through dependence upon operational aircraft.

The first simulator program I would like to present is the UH-1 (Huey). The Army has fielded 22 UH-1 flight simulators at 15 locations world-wide. Each simulator includes four cockpit trainer stations mounted on five degree-of-freedom motion systems, an instructor station and a high speed digital computer. The UH-1 simulator represents the Army's first commitment to advanced rotary wing simulation. It has played a major role in setting the direction for our current and future efforts. Over the years the UH-1 simulator has "flown" more than 1.4 million hours. If this number of hours had been flown in the aircraft, the cost would have been nearly $522 million. When you consider procurement costs for the 22 simulator fleet were $59.9 million, it is obvious that the simulators have indeed been a worthwhile investment. And, as a continued benefit, all 22 of the UH-1 simulators are still being used today and figure in training plans of the active Army, Army Reserve and National Guard for the foreseeable future.

Our second program is the CH-47 flight simulator which replicates the Army's CH-47 (Chinook) medium lift helicopter. This aircraft is used in a combat support role at the division of corps level. Typical missions include troop transport, resupply, and medical evacuation under all weather conditions. Although the external appearance of the flight simulator bears no resemblance to the aircraft, internally it is an

exact replica of the cockpit of the CH-47. The system is mounted on a six degre-of-freedom motion system, has an out the window visual scene, and is entirely controlled by a digital computer system. The instructor station is located inside the cockpit directly behind the crew station. This allows the instructor to directly interact with the trainees while simultaneously maintaining strict control of the training scenario.

We have a total requirement for six of these simulators. Four of these simulators are currently operational, three in conus and one in Europe. Because we are converting our CH-47 fleet to the "D" model aircraft the last two simulators will be produced in the "D" configuration. Conversion of our "C" model simulators to the "D" model simulators begins in FY 84 and will be completed in FY 86. At the same time, we plan to institute, as a planned product improvement, the digital image generator [DIG] visual system in place of the camera model boards that are currently in use on fielded systems. Through FY 85, the Army has requested $76.2 million to develop, procure and convert CH-47 simulators.

The third simulator I will discuss is the AH-1 flight and weapons simulator. The aircraft is a tandem seated gunship equipped with a 20MM cannon in the nose turret and 2.75 inch rockets and tow missiles at wing stores. It is used to provide responsive anti-armor support to ground forces. The external appearance is much the same as the CH-47 flight simulator except there are two separate cockpits—one for the pilot and one for the copilot/gunner. These can operate independently on separate training missions or they can be electronically tied together and operate as a single aircraft for crew training as is most commonly done in the field. The production model cockpit interior is an exact replica of the fully modernized Cobra cockpit and includes an out the window visual scene provided by the laser scan image generator visual system. The simulator provides the capability of practicing nap-of-the-earth flying and, for the first time, weapons delivery skills in a realistic combat environment. Army aviators will now be able to simulate firing all Cobra weapons in a simulator. The system includes the telescopic sight unit, heads-up display, laser range finder, weapons effects video and display of weapon tracer rounds and impacts. The benefits of incorporating weapon delivery into flight simulators are obvious. Not only will aviator readiness improve, but the potential for dollar savings through reduced ordnance expenditure is substantially increased.

The Army has a requirement for nine of these devices. The first three at Fort Rucker, Alabama, Fort Hood, Texas, and Hanau, Federal Republic of Germany, are fielded and operational. You will note that two of these simulators are principally for National Guard use and will be located at Indiantown Gap, Pennsylvania, and Marana, Arizona.

The Army has requested $162.4 million to develop and procure the AH-1 flight and weapons simulators. On the basis of our utilization experience with the UH-1 simulator and the added weapons delivery capability, we expect that this will be an even more cost effective simulation system.

The fourth simulator I will discuss is the UH-60 flight simulator. The production simulator consists of a single cockpit mounted on a computer controlled six degree-freedom-of-motion base. The instructor station located inside the cockpit allows complete control of the training situation at all times. The visual presentation is provided by a digital image generator [DIG], four window, full day-night display. The simulator is designed to provide training in normal, emergency and tactical procedures. The visual system provides a full array of interface with threat vehicles.

The original basis of issue plan for the UH-60 flight simulator called for eight two-cockpit systems. To meet its world-wide training requirements, the simulator configuration was changed to a single cockpit, and a need for sixteen devices including the prototype was apparent. This change allows greater flexibility in aligning the simulators more closely with the distribution and density of aviators the simulator is required to support. Additionally, this distribution plan will provide better overall utilization of the system. Most importantly, however, it will improve our combat readiness posture by allowing greater access to the training device by our UH-60 pilot population world-wide.

We plan to procure 3 UH-60 simulators in FY 84 and 3 in FY 85 with continued procurement through FY 88. To date, $107.8 million has been requested for development and procurement of UH-60 flight simulators.

The AH-64A Apache aircraft is the newest entry into Army aviation. The Apache, a twin engine, four bladed helicopter is operated by a crew of two seated in tandem. The AH-64 can deliver unprecedented firepower quickly and with deadly accuracy, and can operate under low visibility in day or night battlefield conditions. The AH-64 combat mission simulator [CMS] is likewise the newest member of the simulator family. The combat mission simulator has been designed to provide a

training capability for flight, weapons delivery, normal and emergency procedures, and sensor system operation tasks. The simulator will consist of separate pilot and copilot-gunner trainee modules, an instructor position aft of each student, motion subsystems, visual subsystems, and a computer complex. The pilot and copilot/gunner trainee modules will be replicas of the actual aircraft cockpits and each will be mounted on a six degree-of-freedom-motion base. The visual subsystem will provide a state-of-the-art, out the window scene and sensor imagery to each appropriate crew member's video displays. Simulated imagery includes forward looking infrared [FLIR], day television [DTV], and direct view optics [DVO]. Pilot displays consist of the integrated helmet and display sight system helmet display unit [IHADSS HDU] and a panel mounted video display unit [VDU]. Gunner displays include the IHADSS HDU, a target acquisition and designation sight heads down display [TADS HDD] and a tads heads out display [HOD]. The simulator will be operated through the computer complex which will fulfill subsystem interface requirements. The training functions will be controlled from the instructor's station located behind each trainee module. The pilot and copilot/gunner will have the capability to train individually or may train as a team performing an integated combat mission.

The Army has a requirement for seven AH–64 combat mission simulators. Like the other members of the synthetic flight training system, the AH–64 combat mission simulator will be cost and training effective. In the area of cost effectiveness, preliminary analysis show operating costs of less than $300 per simulator hour whereas aircraft operating cost is approximately $2,000/hour.

As in the case of the AH–1 flight and weapons simulator, cost effectiveness becomes even more positive when the benefits of simulated weapons delivery are considered. For example, the cost of "firing" a Hellfire missile in the AH–64 CMS is less than one penny: firing the Hellfire missile costs nearly $45,000.

Of equal importance with cost avoidance, is training effectiveness of the combat mission simulator. Much of the military advantage of the AH–64 is directly related to the aircrew's competency and proficiency in employing the advanced sensors and weapons on board the aircraft to their outer limits. Likewise, proficiency in the delivery of on-board ordnance will require access to laser safe firing ranges and an expenditure of ammunition that may not be readily available. The AH–64 combat mission simulator allows Army aviators to train to maximum effective range on a day-to-day basis. Additionally, through simulation, aviators will be able to safely hone their skills in all environmental conditions day, night, or adverse weather.

The Army expects to pay $227.5 million to develop and procure the AH–64 combat mission simulators.

As you requested, I would like to direct attention now to our major ground based weapon system training simulators. LtG Chavarrie has already mentioned two of the Army's ground based simulation training systems—Stinger and multiple integrated laser engagement system [MILES]. It is impossible to address all of our remaining on-going systems, however I would like to highlight one which I feel warrants specific attention. This training simulation system is the armored vehicle conduct of fire trainer [COFT].

The ever increasing costs of conducting tank gunnery training, coupled with the continuing problem of crew turbulence and range limitations, made it necessary for the Army to take a quantum leap forward in its approach to maintaining combat readiness in our ground weapons systems. With the technology of flight simulators as a base, the conduct of fire trainer allows tank and infantry battalions to keep their gunnery skills razor sharp every day of the week.

Initial deliveries of the conduct of fire trainer [COFT] will begin in FY 85 and procurement will continue through FY 86. The Army plans to procure approximately 240 of these simulators at an estimated cost of $544.3 million.

The COFT will be deployed configured for training M1, M60A3, and M2/3 gunners and commanders. The device consists of five major assemblies. Of these, the instructor/operator station, visual system, a computer system and shelter system, are common to all configurations. The fifth assembly, the crew station (gunner and tank/track commander) is a high-fidelity duplication of the combat vehicle interior and is trainer peculiar. This gunnery simulator uses computer based visual simulation, replicated crewmen turret stations, and environmental effects (noise, recoil, etc.) to create realistic training scenarios. Multiple target engagements can be simulated, and gunner's skill can be practiced in a variety of degraded conditions. The trainer can simulate the conditions which soldiers can realistically expect to find on the battlefield to include incoming enemy fire, limited visibility, and equipment malfunctions. COFT will increase combat readiness as realistic training will be conducted year round in any weather and, like flight simulators, at substantially reduced cost.

Use of simulators can be expected to grow in future Army training programs. I have already presented information that highlights the cost effectiveness of the devices. However, in addition to making the best use of limited resources, simulators provide many other vital benefits including improved and more flexible training capability, extending the useful life of the actual hardware, reducing accidents and reducing requirements for ranges and training facilities.

Likewise we have found that effective training simulation provides training efficiency which in turn yields both increased battlefield effectiveness and operational readiness. In fact, there is no other medium that completely integrates tactics, enemy, terrain, electronic warfare, laser, FLIR, TV, direct vision optics and all other elements of the modern battlefield than the simulator. In short, some training can only be conducted through simulation.

In light of these benefits it is obvious that use and application of simulators should be maximized. However, there are limits to these benefits. Although simulators by themselves provide effective training, the greatest benefits are achieved by combining simulation training with training on the primary piece of equipment. Therefore, we see the greatest future benefits to be derived in training programs where simulators complement rather than replace actual hardware. Determining the correct percentage of training time and the correct tasks to be trained on each medium is an area of on-going study.

We intend to continue to explore ways to effectively weave simulation into our training programs. Initial qualification and continuation training of individuals are areas which have already proven to be effective applications of flight simulation training. We have only touched the surface in applying aviation training lessons learned to our ground weapons systems. There is little question that this latter area is a fruitful one in which to apply our future efforts.

I'd like to turn now to the third key area of my statement—technology. Simulation technology is moving forward by leaps and bounds. Concepts which five years ago were thought of as unobtainable before the turn of the century are here now. The Army has taken steps to remain abreast of this rapid forward movement. We have an on-going visual system component development program with the goal of providing a wide field of view, high detail computer generated imagery system for the AH–64 combat mission simulator and subsequent flight simulators. We seek to advance computer generated imagery to the point that nap-of-the-earth flight, weapons effects and target acquisition and identification can be fully supported. Attaining this goal requires special data base management systems and techniques which can use defense mapping agency data or data from other sources. Additionally, this capability would enable transformation of such data into computer generated scenes that replicate any sector of the world. The benefits to training are enormous. For the first time, Army aviators would be able to simulate flight through computer generated scenes of the real world before their first combat mission. Without question, beforehand knowledge of the terrain will improve "first day" combat effectiveness, eliminate pilot mistakes and/or hesitation caused by unfamiliarity with terrain and ultimately raise both combat survivability and mission accomplishment.

The rotorcraft systems integration simulator [RSIS] is a second program aimed at moving Army aviation simulation technology forward. This joint Army/NASA program has as its objective development of an advanced rotorcraft research and development simulation capability that supports basic rotorcraft technology and training simulation. When completed the RSIS will allow for development of better aircraft design as well as enable earlier development and fielding of training flight simulators. The Army's light helicopter experimental program [LHX] is the first that will have the benefit of RSIS. By requiring each contractor selected for engineering development to provide a dedicated simulator cockpit, we will be able to field a training simulator well before fielding the first production model aircraft.

A third key area in simulation technology is team training. Up until now, most training simulation has been aimed solely at improving individual skills. Of course, on today's battlefield success comes not only from individual combat skills but from the synergistic effect of combined arms teams. Army aviation will play a prime role in this synergism. The aviation combined arms team trainer [ACATT] begins concept formulation in FY 85 with initial fielding of a prototype trainer in FY 89. The ACATT will provide a simulation capability whereby we will train in the same manner in which we will fight—in teams. This device will allow interface between scout and attack helicopters on a simulated, computer generated battlefield. A modular design will allow us to configure the device to match the aviation unit organization the device will support. Plus, such design will enable us to add other combined arms team members to the simulation system in the future.

As mentioned earlier, technology gains in aviation simulation are in many ways applicable to our ground weapon system training requirement. Computer generated imagery and team training concepts are being explored. For example, we are investigating development of an armored platoon trainer. This device will be aimed at improving tactical maneuver skills of an entire tank platoon in the same manner as ACATT.

The Army maintains a solid leadership position in developing the training simulation technology base. We actively direct efforts to remain informed on state-of-the-art techniques that will allow improved training capabilities. Key items that warrant mention today are our work to employ ADA high order software language in training simulators, to use microprocessors in training simulation, and to employ modular design in development of training devices. In each case, successful application will lower cost and reduce schedule requirements for further simulation procurements.

To be effective in employing both known simulation techniques and emerging technologies, the Army actively cooperates and exchanges information with the Office of the Secretary of Defense and the other armed services. Many of the exchanges occur informally on a routine basis while others are more formal. It is impossible to list even a majority of our initiatives in the time allotted today. However, to provide the flavor of interservice cooperation I will present a few of what I consider to be important areas.

First of all, as many committee members are aware, our program manager for training devices [PM-Trade] is collocated with the Navy's Training and Equipment Center in Orlando, Florida. A significant product of this collocation in addition to purely information exchange is the benefit of a common technical and business base. In effect, many of the employees developing training devices for the Army and the Navy are members of the same organization.

A second element worth mentioning is Army participation as a member of the Joint Logistics Commanders Technical Coordinating Group on Simulators and Training Devices. Participation of all services is aimed at methods that will not only improve training effectiveness but will also shorten the acquisition cycle and lower acquisition costs.

Army, Air Force, and Navy cooperation in developing advanced computer generated imagery visual systems is a third direct area of interservice cooperation. The visual system component development program [VSCDP] already mentioned is the Army's product in this effort.

Finally, all services are actively seeking to apply ADA high order language to simulation through formal agreement. It is expected that by working together we might all be able to implement ADA by FY 87.

The Army has come a long way from our first use of "make do" converted flight trainers. We are proud of our accomplishments in development and utilization of flight simulators over the past 15 years. We are not satisfied to sit back on our laurels. Rather, we have taken positive steps to continue movement forward at a pace equal to the forward momentum of technology—in many cases, we are leading the way. We are applying the lessons learned in flight simulation to the training needs of our ground weapons systems. The Army leadership is convinced that training simulation is the key element in maintaining a high state of operational readiness in an environment of limited resources.

Mr. Chairman and members of the committee, this completes my statement. Again, thank you for the opportunity to discuss this important facet of Army programs.

Senator GOLDWATER. One question pops into my mind. Why can you not simulate autorotational problems?

General KENYON. You can simulate an engine failure, sir, and the entry into autorotation where you try to conserve your rotor rpm's. The only difficulty is, at that point just prior to touchdown with the collective pitch application in the last—well, you flare about 15 feet, and about 3 feet off the ground.

The fidelity in the simulator is such that you just cannnot effectively do that last 3 to 5 feet and understand exactly where that aircraft skid is. The simulator does, however, provide the capability to carry the maneuver to the ground.

Senator GOLDWATER. I can agree with that. But one of the difficulties in training is how a pilot reacts in autorotation to get the nose down and get the speed up. Can you do that part of it?

General KENYON. Yes, sir, that can be done. The simulated engine failure and the entry into autorotation can and is done in all of those simulators today. It is just that final touchdown.

Senator GOLDWATER. All right. Thank you very much. I will have a few more questions, but that was a very good presentation.

Now we have the Navy, Admiral Dunleavy.

STATEMENT OF REAR ADM. RICHARD M. DUNLEAVY, U.S. NAVY, DIRECTOR, AVIATION MANPOWER AND TRAINING DIVISION, OFFICE OF THE CHIEF OF NAVAL OPERATIONS, ACCOMPANIED BY CAPT. M.M. SCOTT, U.S. NAVY, DIRECTOR, WEAPONS TRAINING DIVISION, NAVAL AIR SYSTEMS COMMAND; AND CAPT. R.A. MONTGOMERY, U.S. NAVY, HEAD, AVIATION TRAINING DEVICE REQUIREMENTS BRANCH, OFFICE OF THE CHIEF OF NAVAL OPERATIONS

Admiral DUNLEAVY. Good morning, Senator.

It is a real pleasure personally to be here to see you again. I have with me today Capt. Milt Scott, who is the program manager for aviation simulators and training devices at NAVAIR, and Capt. Bob Montgomery, who works with me at the Pentagon as head of our Training Device Requirements Branch.

Representing the Marine Corps is Lt. Col. Bob Lewis, who is the Training Support Division head up at Marine Corps headquarters.

Mr. Chairman, I would like to thank you and this committee for the opportunity to discuss training systems and, specifically, simulation in Naval aviation training today, and your continuing support in this critical area.

I am pleased to inform you that the Navy has continued its vigorous pursuit of simulation in aviation training. We are devoting an increasing amount of our resources to training systems, of which simulators are a key element.

For example, in fiscal year 1980, the NAVAIR budget for training systems, acquisition was $164 million. Today, in 1984, it is $491 million. There are solid reasons for this emphasis.

First, it is a very cost effective investment. The acquisition and operating costs of aircraft have sharply increased. Preparatory training in simulators, conducted at a fraction of the cost, makes practice in the aircraft more productive and safer.

The growing scope and complexity of the training task, and the prohibitive cost and support requirements of in-flight training, have irrevocably shifted much of the training burden from operational equipment to training devices.

The Navy and Marine Corps presently utilize some 430 major operator/air crew training devices in the active fleet, the training command, and the reserves. This family of simulators now covers almost the full spectrum of procedures, skills, and tactical applications necessary to mission readiness in the great variety of combat scenarios.

I would like to address some areas in which we believe particularly significant strides have been made.

First, there is increased user acceptance. Over the years, the education of the users and the operators in the training value of simulators and the advancing technology which has produced greater availability and realism have fostered the acceptance and enthusiasm which are major factors in effective utilization.

The active involvement of the fleet project teams, which are composed of fleet training and operational experts and other users in the simulator development process, has had a positive influence.

It has also contributed significantly to the timely delivery of more usable and acceptable trainers.

A second area of progress is that we are utilizing our simulators more effectively than ever before. In addition to increasing utilization, the hours in the simulator are being made more productive. The simulator has been integrated into the Fleet Readiness Squadron and the operational squadron curricula in a manner which directly complements academic and aircraft training.

The resultant integrated syllabi clearly enhances the simulator role. Advances in trainer technology have allowed us to improve existing simulator capability and to expand the role of simulator into new areas of training.

For example, the air-to-air laser gunnery simulator which we will put on T-2's in our training command in 1985 adds another dimension to this training and alleviates some of the difficulties in our limited, target range availability.

Visual systems are improving. The new helicopter visual systems provide much more effective shipboard landing and takeoff training through better definition and increased field of view.

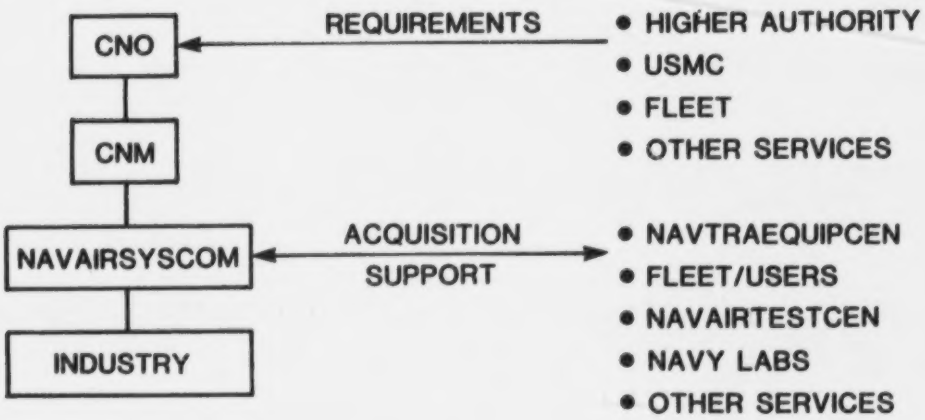
The new A-7 video disc visual system now operational at Cecil Field represents a significant advance in tactical air training and provides real world imagery and improved resolution, fidelity, brightness, ground growth, and mapping in air to ground weapons delivery simulation.

The basic hardware in the system is also being utilized for additional R&D efforts to further advance visual technology. We are making a concerted effort to provide better maintenance and support packages and to continue to upgrade in service trainers through modification and modernization.

We are transitioning from organic support to Contractor Operations and Maintenance of Simulators, the COMS program. The immediate result has been considerably increased trainer availability at a lower cost. During the remainder of my remarks, I will discuss our policy of acquiring and using simulators.

Some programs in the research, procurement, and operational phases will be highlighted. I will also address new technology and the cooperative efforts with other services.

TRAINING SYSTEM MANAGEMENT



As a matter of policy, in keeping with congressional and DOD guidance, our acquisition and management procedures are dedicated to developing a training system that is fully integrated with the weapons system it supports.

The structure depicted here is a straight line organization which manages the acquisition of the total aviation weapon system. This total program concept provides centralized management and accountability under the weapon system program management framework for both the operational and the training system deployed.

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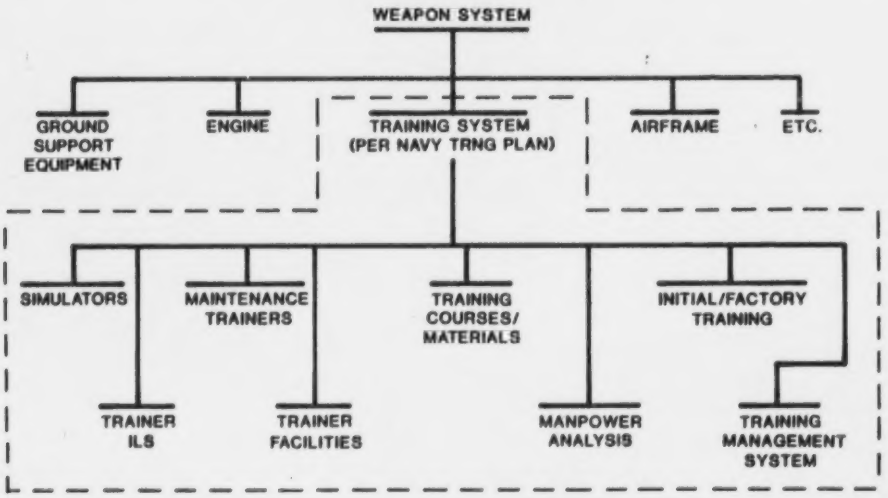
AVIATION
WEAPON SYSTEM–TRAINING SYSTEM
RELATIONSHIP



The training system, and I really do want to stress the word "system," is composed of the primary elements shown here. Inside the dotted line you will see the total package, which covers all aspects of air crew and maintenance training.

Based on years of hard experience, we view the system concept as vital. Within this context, simulators are not stand-alone items in their own right. They are instead one element of the training system.

The training system in turn is a major integral element of the weapons system program. Dedicated simulators, and training systems, have no inherent priority or even reason for being, except the readiness of the parent weapon system.

As a system within a system, training must be planned, developed, and introduced as a coherent package, so that all the parts are mutually supporting. They must also be totally integrated and compatible with the weapons system development process, schedule, configuration, and operating and maintenance concepts.

To this end, we have strengthened and upgraded dedicated training system managment with the Naval Air Systems Command, and directly tied it to the weapons systems at the program management level.

We have also established a firm policy that the training system must be ready and in place before weapons system Initial Operational Capability or commencement of Fleet Readiness Training. The most critical and difficult period in any training program is preparing for fleet introduction.

Configuration has not stabilized. Personnel are unfamiliar with their aircraft. Maintenance and support problems are at their maximum. If the simulators are not available, pilot training requires

that fleet aircraft be diverted. The student flow is disrupted and the costs increase dramatically. In many case required operational capabilitly simply cannot be achieved without the training devices in place. Training devices must match aircraft configuration if they are to provide quality training.

It is normally less expensive and faster to incorporate aircraft changes while the simulator is still in production rather than to try to retrofit it later. However, this often brings us face to face with our requirement for timely delivery.

When this happens, a decision must be made within the program management framework on the basis of the impact of the total weapons system program.

Another factor which mandates full integration of the weapons system in the simulator development and acquisition process is their converging technology. At one time aircraft were basically hardware and simulators were computer gadgets. Today's aircraft are software-intensive.

The F/S–18, for example, has a cathode ray tube instrument panel with computer-drawn displays. Maintaining configuration with the software-intensive aircraft dictates a much greater use of aircraft common equipment in the simulator.

This has increased the initial simulator investment cost, but avoids prohibitive update costs of both time and dollars later on. Today's simulator is basically "an aircraft in a room."

The F/A–18 and SH–60B LAMPS MK III trainer suites, which I will briefly describe later, represent the present state of the art in simulator contribution to aviation system mission readiness.

Additionally, I would note that in the T–45 training program we are establishing a new benchmark in total integration of the planning, development, acquisition, operation, and life cycle management of the aircraft and its training system.

We are making a continuing and increasing effort to design and use our trainers for maximum efficiency and effectiveness. Part task, or procedures, trainers, operational flight trainers, and full mission, or weapons system trainers are selected, designed, and used in a building block approach tailored to each major aircraft and total training requirements.

A primary focus continues to be on increasing the scope and the realism of visual simulation together with appropriate motion cuing. Another major thrust is for the provision of more complete and accurate command and control, tactical intelligence, and electronic warfare inputs.

And another key consideration in present management is that we do not reinvent the wheel every time we develop a new training system or simulator.

In front-end analyses and training system development we carefully build on past experience in determining the skill and the learning objectives, selecting the means for their achievement, determining the family of equipment, including simulators required, setting the course length, and overall ensuring completeness and coherence.

In simulator design development, we seek a maximum transfer of technology and components from existing devices to emerging requirements. The T–45 training system, for example, directly incor-

porates amost 75 percent of the technological advances achieved in the F/A-18.

Seventy percent of the software, 75 percent of the instructor station design, and 100 percent of the motion cuing are real time interfaces with both programs. This affords large savings and development costs in time, procurement unit costs, and through greater commonality, life cycle support.

Air-to-surface weapons delivery continues to present a formidable challenge in the great complexity, flexibility, and variety of simulation requirements to meet our extensive mission requirements. This challenge is, of course, common to all the services. Every aspect and breakthrough in emerging technology will continue to be brought to bear to improve capability in this critical area.

ROLE OF SIMULATORS

Supplement in-flight training.
Least cost classroom, simulator, aircraft sequence: Acquire knowledge; develop skill; achieve confidence; and increase flying hour productiveness.

I have highlighted our integrated system, building block, least cost approach in both design and application. As to how we use our simulators, let me just say that we have not wavered in our view of a supplemental, rather than substitution, role for simulators versus actual in-flight training.

There is no substitute for hands-on, in-flight experience in preparing for operational and combat flying. In the system approach to aviation training, we impart knowledge in the classroom lectures and individual computer-aided learning techniques.

Step by step with the classroom academics, we gain familiarity with the system equipment and develop skills, procedures, and correct habits in the simulators. We then refine the skills and gain the critical element of confidence through in-flight practice in the most realistic environments and scenarios we can create. The result is a greatly enhanced productivity from every flying hour committed to training.

The training benefit of simulators in this application derived from affordability, practicality and safety. Let me make a critical point here about affordability. The trends in aircraft, mission and threat complexity, demand for realism, and diminishing reaction times and margins for error are all well established. This inevitably drives the training requirements, quantitatively and qualitatively, upward.

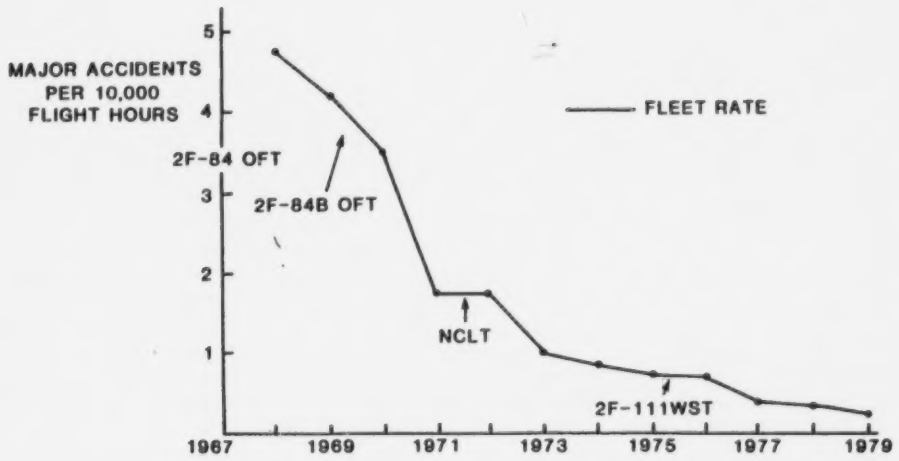
More and better training means higher costs. Training and simulator costs are not going to decrease or, by any realistic projection, remain constant. A frequently unrecognized benefit of simulators, then, is to constrain the cost growth in essential training.

We cannot afford the aircraft training weapons, flying hours, facilities, supporting forces, or time to train in aircraft alone. Nor can we afford the hazards and loss of life and material inevitable in the actual practice of certain emergency procedures.

In addition to affordability considerations, actual electronic warfare, antiair warfare, antisubmarine warfare, and combat scenario inputs are effectively unavailable. We must make up for what we cannot afford, or otherwise cannot do, by using actual forces through continually increasing capability in our simulators.

It will not be inexpensive, but it is, in my judgment, not just the least cost, but the only way to go.

A-7 MAJOR ACCIDENT RATE
From Naval Safety Center Summaries



In safety alone, although this assessment contains a subjective element, flight simulators are more than paying their way. Since we last testified 4 years ago before this committee, we have conducted a careful correlation between the introduction of A-7 simulators and accident data.

The A-7 analysis established that the majority of the reduction in the A-7 accident rate was due to reduced pilot error accidents in those flight evolutions learned in simulators. Comparable aircraft, which were simulated to a lesser degree, suffered from higher pilot error accident rates in the same flight evolutions. The results of this fleet project team analysis indicate that the A-7 simulator suite saved light attack aviation 25 A-7 aircraft and 7 aviators through the reduction of pilot error major accidents over a 5-year period.

I must state that while one may debate the exactness of the numbers, it is certain that numerous lives and aircraft have been saved by the A-7 simulators.

MAJOR ACCIDENT SUMMARY

[Dollar amounts in millions]

	Hours	Accidents		Cost
		Number	Rate	
Calendar year:				
1970	2,978,433	402	13.50	$446.6
1971	2,790,773	258	9.24	335.4

MAJOR ACCIDENT SUMMARY—Continued

[Dollar amounts in millions]

	Hours	Accidents		Cost
		Number	Rate	
1972	2,662,829	252	9.46	355.9
1973	2,371,502	206	8.69	328.4
1974	2,151,535	147	6.83	220.5
1975	2,141,506	137	6.40	264.6
1976	1,974,772	128	6.48	263.7
1977	1,981,328	107	5.40	322.0
1978	1,948,671	109	5.59	418.5
1979	1,911,859	103	5.39	311.4
1980	1,936,360	115	5.94	392.9
1981	1,966,464	95	4.83	394.7
1982	2,018,752	90	4.46	339.0
1983	2,004,069	87	4.34	522.0
1984 (through June)	1,030,610	30	2.91	89.2

Subsequent to the A–7 analysis, our overall experience substantiates this finding. While almost every threat to safety and training and peacetime operation is constant or increasing, our accident rate in major high-risk aircraft types continues to come down.

Senator GOLDWATER. Is that the A–7?

Admiral DUNLEAVEY. That is Navy, Marine Corps-wide.

No reasonable observer can doubt the contribution of simulators to this remarkable achievement. Note that while accident numbers and rate are steadily decreasing, the dollar cost is not. Accidents are not only tragic, but are progressively expensive. More and better simulators are a major factor in accident cost avoidance.

I would now like to describe briefly four of our current major simulator acquisition programs, the SH–60 Bravo, the AV–8B, the F/A–18, and the T–45 training system.

MAJOR TRAINING PROGRAM STATUS

AIRCRAFT TYPE
SH-60B

AIRCRAFT IOC
JUL '84

SITE	SIMULATOR	RFT
NORTH IS., CA	OFT #1	6/84
	WTT #1	6/84
	WTT #2	3/85
	WST #1	9/86
MAYPORT , FL	OFT #2	3/85
	WTT #3	11/85
	WTT #4	6/86
	WST #2	1/87

The SH-60 Bravo represents the first state of the art training system for a Navy helicopter. We now have two training squadrons with the simulators as shown. The operational flight trainer [OFT] has motion and a visual display.

It provides training in flight maneuvers, takeoffs and landings, navigation and communication, malfunctions, and emergency recovery procedures. The weapons tactics trainer [WTT] provides avionics subsystem training for the tactical officer and sensor operator. The weapons system trainer [WST] provides both the flight training and the tactical team full mission training as a coherent unit.

MAJOR TRAINING PROGRAM STATUS

AIRCRAFT TYPE AV-8B		AIRCRAFT IOC AUG '85
SITE	**SIMULATOR**	**RFT**
CHERRY PT., NC	AST #1	10/83
	OFT #1	3/85
	WTT #1	8/85
YUMA, AZ	AST #2	6/87
	OFT #2	CY-87
	WTT #2	CY-87

The AV-8B also has two training squadrons. In addition to the operational flight trainer and the weapons tactics trainer, each site will be equipped with an air crew systems trainer [AST]. The AST is a part-task trainer which has no motion or visual system. It was designed to train pilots in hands-on-throttle and stick operations, the head-up display, radar warning, and defensive electronic countermeasures.

Senator GOLDWATER. Let me ask you, a couple of years ago you had—the marines had a very high accident rate in the AV-8. It has come down. Could you attribute that to any great extent to the use of simulators? Or is it related to pilot experience?

Admiral DUNLEAVY. I believe it is a combination of both, sir. Probably simulators would be a heavy influence, but more experience with the aircraft is also a factor. Simulators are now playing more and more of a role in safety across the board, but especially, recently, in the AV-8B.

Senator GOLDWATER. But the accident rate has come down rather dramatically.

Admiral DUNLEAVY. Yes, sir.

Senator GOLDWATER. And I have a question. Can you attribute that in any way to the simulators? Or is it due to the fact that you have acquired more pilot experience before you put the man into the 8?

Admiral DUNLEAVY. I believe it is to the simulators, just as with the simulators in the A-7. You saw a stepdown as we got more and more sophisticated simulators into the program. We saw the accident rate come further down with the AV-8 also, sir.

Senator GOLDWATER. Well, we will follow that up later.

Admiral DUNLEAVY. Yes, sir. The F/A-18 operator training suite consists of a part task trainer, an operational flight trainer and a weapons tactics trainer.

MAJOR TRAINING PROGRAM STATUS

AIRCRAFT TYPE
F/A-18

AIRCRAFT IOC
AUG '82

SITE (NAS)	SIMULATOR	RFT
LEMOORE, CA	PTT #1	5/82
	OFT #1	7/82
	#3	6/85
	WTT #1	1/84
	#4	6/85
	#6	7/90
CECIL, FL	PTT #2	6/85
	OFT #2	2/85
	#5	4/86
	WTT #3	7/85
	#5	6/90
	#7	6/91

The PTT is the same type as the AV-8B AST. The operational flight trainer simulates the entire F/A-18 flight envelope and land/carrier operations. The WTT, which you saw earlier in the domed building, provides air combat maneuvering training utilizing a 40-foot spherical projection dome.

This device provides training in air-to-air missilery, radar imagery, tactics and aircraft normal and emergency systems operation.

MAJOR TRAINING PROGRAM STATUS

AIRCRAFT TYPE
F/A-18

SITE (MCAS)	SIMULATOR	RFT
EL TORO, CA	PTT #3	1/88
	OFT #7	1/88
	WTT #2	2/85
BEAUFORT, SC	OFT #4	2/86
IWAKUNI, JAPAN	OFT #6	2/87
KANEOHE, HI	OFT #8	1/89

The Marine Corps will receive its first WTT at Marine Corps station at El Toro in early 1985, with follow-on simulators as shown.

MAJOR TRAINING PROGRAM STATUS

AIRCRAFT TYPE
T-45

AIRCRAFT IOC
OCT '90

SITE	SIMULATOR	RFT (INITIAL)
KINGSVILLE, TX	IFT #1-#4	6/90
	OFT #1-#8	1/91
MERIDIAN, MI	IFT #5-#7	11/92
	OFT #9-#15	9/92
BEEVILLE, TX	IFT #8-#10	7/94
	OFT #16-#22	5/94

The T-45 training system, developed for the intermediate and advanced phase of the Naval Air Training Command strike pipeline

consists of 10 instrument flight trainers (IFTs) and 22 operational flight trainers. These devices will be cited as shown.

The IFT provides a full spectrum of instrument flight capability. The OFT will include a visual system with a g seat/g suit, buffer cuing, and will provide student pilot training in formation flying, field and carrier takeoffs and landings, tactical navigation, air-to-ground weapons delivery, air combat maneuvering, and normal and emergency procedures.

The schedule of these two training devices, the T-45 trainer aircraft, and a computer-assisted academic and flight support instructional system, will be managed as an entity by a computer-based training integration system.

Senator GOLDWATER. Let me ask you, when do you put the midshipmen into the training, before flight or after flight?

Admiral DUNLEAVY. Before flight, sir. In referring to your question to the Army General, I will give you an example. In the F/A-18 we take a fellow out of the training command, and before we put him in the F/A-18, he has all of his classroom training and about 6 to 10 hours in simulators before we put him into the two-seat F/A-18.

Senator GOLDWATER. I am talking about the T-45, the new man.

Admiral DUNLEAVY. He will have simulator training before he is put in the airplane.

Senator GOLDWATER. You put him in the simulator first before the aircraft?

Admiral DUNLEAVY. Yes, sir.

Senator GOLDWATER. How many hours does he get in the simulator?

Admiral DUNLEAVY. We are developing that right now, and I would estimate that now at about 20 hours.

Senator GOLDWATER. Thank you.

Admiral DUNLEAVY. Emerging programs of significance include the JVX, the F-14D, the A-6E Upgrade, the E-6A, and the Carrier Helo.

In each case we are looking at the whole system as we develop it. As we purchase these aircraft, the simulators will come along with them.

NEW TECHNOLOGY/JOINT EFFORTS

High altitude source imagery data bases.
Separate region mapping techniques.
Area of interest projection.
Computer generated target insertions/overlays.
Computer assisted mission planning.
On board/in-flight simulation/stimulation.

Now I will turn to my last item, new technology and joint efforts, and here is where the future lies, Senator Goldwater, in my opinion.

The high-altitude source imagery data bases is a joint Navy, Air Force, and Defense Mapping Agency project. It involves the development of a process to generate a photographic data base from transformed high-altitude source imagery.

Through computerized modeling, images are transformed into a synthesized low-altitude photo which contains vertical terrain

relief, manmade feature elevations, horizons, and skylines. These photos are computer-regenerated to provide a real time, omnidirectional, fly through, visual scene.

One objective of this effort is to improve technology to reduce throughput time per photo from about 2 hours to 10 minutes. The separate region mapping effort is directly related to the high-altitude project just discussed. It provides the necessary improvement in image fidelity by correcting paralax distortions introduced when transforming an overhead perspective to the observer's eye point.

This restores accuracy to perspective and corrects distance measurement errors. Thus, correlation between common ground points and terrain data is maintained to provide high resolution and accurate area/target analyses. Area-of-interest projection systems permit the instantaneous projection of extremely high resolution images in the pilot's field of view, while supplying adequate but lower fidelity detailed imagery for peripheral viewing.

This approach should permit higher fidelity images to be viewed by the pilot at lower cost than the present day wide view high fidelity visual systems we now employ. We are working closely with the Air Force on this project.

Computer-generated target insertum/overlays technology is developing techniques to permit the insertion of computer-generated synthesized targets into visual system image data bases. Inserted targets will be capable of motion and will have a 3-D realism with proper shadowing for air-to-air, air-to-surface, and surface-to-air applications in the highly interactive scenarios.

The computer-assisted mission planning project involves the integration of computer-aided mission planning systems with high altitude source imagery data bases to significantly enhance operational mission planning. Poststrike analysis capability will also be enhanced.

This technology will provide a system to generate optimal routes through heavily defended areas based upon the latest order-of-battle intelligence. It utilizes terrain, radar masking, and the suppression capabilities to effect the highest probability of mission success.

In addition to individual mission planning, this effort will have a significant application to command and control center display technology. This project is being conducted in concert with the Joint Cruise Missile Program Office. The objective of the onboard, in-flight simulation/stimulation project is to provide higher quality in-flight training.

This concept is to use onboard or imbedded simulators and simulators to excite aircraft systems. These systems will permit tactical aircrews to conduct dynamic training scenarios at reduced cost and in the absence of otherwise critical external support forces.

Examples of training which will be conducted include air-to-air intercept and engagement, electronic warfare, and operator training for specialized sensors such as infrared and synthetic aperture radar.

In selling this, Senator Goldwater, the bottom line is safety and operational readiness. Due to the factors I have mentioned, the real minimum win or lose readiness objectives are not getting easier or cheaper to achieve. The total exploitation of all simulator capabil-

ity we can design and build is necessary to keep essential training effective and affordable.

Mr. Chairman, this completes my statement. Again, I thank you for your time here today to discuss naval aviation, especially simulation.

[The prepared statement of Admiral Dunleavy follows:]

PREPARED STATEMENT OF REAR ADM. RICHARD M. DUNLEAVY, U.S. NAVY, DIRECTOR, AVIATION MANPOWER AND TRAINING DIVISION, OFFICE OF CHIEF OF NAVAL OPERATIONS (AIR WARFARE)

Mr. Chairman, I would like to thank you and this committee for the opportunity to discuss training systems, and specifically simulation, in naval aviation training, and for your continued support in this critical area.

I will present an overview of the present status of naval aviation simulator acquisition and use and highlight certain aspects of this most important program.

I am pleased to inform you that the Navy has continued its vigorous pursuit of simulation in aviation training. We are devoting an increasing share of our resources to training systems of which simulators are a key element. For example: in fiscal year 1980, the NAVAIR budget for training systems acquisition was $164M; in fiscal year 1984, it is $491M. There are solid reasons for this emphasis. First, it is a very cost effective investment. The acquisition and operating cost of aircraft have sharply increased. Preparatory training in simulators, conducted at a fraction of the cost, makes practice in the aircraft more productive and safer. The growing scope and complexity of the training task, and the cost and support requirements of in-flight training have shifted much of the training burden from operational equipment to training devices.

The Navy and Marine Corps presently utilize some 430 major operator/aircrew training devices in the active Fleet, Training Command and Reserves. This family of simulators now covers almost the full spectrum of procedures, skills, and tactical applications necessary to augment mission readiness in the great variety of Naval combat scenarios.

I would like to address some areas in which we believe particularly significant strides have been made:

First there is increased user acceptance. The education of users and operators in the training value of simulators and an advancing technology which has produced more dependable availability and realism have fostered the acceptance and enthusiasm which is a major factor in effective utilization. The active involvement of the Fleet Project Teams, composed of fleet training and operational experts, and other users, in the simulator development process has also been a positive influence and has contributed significantly to the delivery of more usable and acceptable trainers.

A second area or progress is that we are utilizing our simulators more effectively than ever before. In addition to increasing utilization, the hours in the simulator are being made more productive. The simulator has been integrated into the Fleet Readiness Squadron, (FRS) and operational squadron curricula in a manner which directly complements academic and aircraft training. The resultant integrated syllabi clearly enhance the simulator role.

Advances in trainer technology have allowed us to improve existing simulation capability and to expand the role of simulators into new areas of training. For example, the air-to-air laser gunnery simulator adds another dimension to this training and alleviates some of the difficulties in our limited target range availability. Visual systems are improving. New helicopter visual systems provide much more effective shipboard landing and takeoff training through better definition and increased field of view. A new A-7 visual system, now operational, employing video disc technology, will significantly enhance the tactical air community by providing real-world imagery, improved resolution, fidelity, brightness, ground growth and mapping in air-to ground weapons delivery simulation. The basic hardware in this system is also being utilized for several additional R&D efforts to further advance visual technology.

We are making a concerted effort to provide better maintenance and support packages, and to continue to upgrade in-service trainers through modification and modernization. We are transitioning from organic support to Contractor Operation and Maintenance of Simulators (COMS) which is resulting in significantly increased trainer availability at reduced costs.

During the remainder of my remarks, I will discuss our policy for acquiring and using simulators. Some programs in the research, procurement and operational

phases will be highlighted. I will also address some of the new technology and cooperative efforts with other services.

As a matter of policy, in consonance with Congressional and DoD guidance, our acquisition and management procedures are dedicated to developing a training system that is fully integrated with the weapons system it supports. The training system is a total package which covers all aspects of aircrew and maintenance training and remains an inherent part of the weapon system program from cradle to grave.

The training system, and I stress the word system, is composed of these primary elements: simulators, maintenance trainers, trainer integrated logistic support and facilities, training courses/materials, initial/factory training, manpower, and a training management system. This system must be planned, developed and introduced as an coherent package so that all the parts are mutually supporting and remain in step with the parent weapon system.

We have also established a firm policy that the training system must be ready and in place before weapons system Initial Operational Capability (IOC) or commencement of FRS training. The most critical and difficult period in the training program is preparing for fleet introduction. Configuration has not stabilized; personnel are unfamiliar with the aircraft; maintenance and support problems are at their maximum. If simulators aren't available, pilot training requires that fleet aircraft be diverted, the student flow is disrupted, and costs increase dramatically. In many cases required operational capability simply cannot be achieved without the training devices in place.

Training devices must match aircraft configuration if they are to provide quality training. It is normally less expensive and faster to incorporate aircraft changes while the simulator is in production rather than to retrofit it later. However, this often brings us face-to-face with our requirement for timely delivery. When this happens, a decision must be made within the program management framework on the basis of the impact on the total weapon system program.

An additional factor which mandates full integration of the weapon system—simulator development and acquisition process is the convergence of their respective technologies. At one time aircraft were basically hardware and simulators were "computer gadgets". Today aircraft are software intensive. The F/A-18, for example, has a cathode ray tube instrument panel with computer drawn displays. Maintaining configuration with these software intensive aircraft dictates much greater use of aircraft common equipment in the simulator. This has increased the initial simulator investment cost but precludes prohibitive downstream update costs in terms of both dollars and time. Today's simulator is basically "an aircraft in a room".

We are making a continuing and increasing effort to design and use our trainers for maximum efficiency and effectiveness. Part task, or procedures, trainers, operational flight trainers, and full mission or weapon system barriers are selected, designed, and used in a building block approach tailored to each major aircraft and total training requirement. A primary focus continues to be on increasing the scope of realism of visual simulation, together with appropriate motion cueing. Another major thrust is for provision of more complete and accurate command and control, tactical intelligence, and electronic warefare inputs.

In this respect, the F/A-18 and SH-60B LAMPS MK III trainer suites, which I will briefly describe later, represent the present state of the art in simulator contribution to aviation system mission readiness. Additionally, I would note that in the T-45 program, we are establishing a new benchmark in total integration of the planning, development, acquisition, operation, and life cycle management of the aircraft and its training system.

A final key consideration in present management is that we do not re-invent the wheel every time we develop a new training system or simulator. In front-end analyses and training system development, we carefully build on all past experience in determining skill and learning objectives, selecting the means for their achievement, determining the family of equipment, including simulators, required, setting course lengths, and, overall, ensuring completeness and coherence. In simulator design and development took, we seek a maximum transfer of technology and components from existing devices to emergent requirements. The T-45 Operational Flight Trainer, for example, directly incorporates almost 75% of the technological advances achieved in the F/A-18 trainer (70% of software, 75% instructor station design, 100% motion cueing, 95% real time interfacing). This affords large savings in development cost and time, procurement unit costs and, through greater commonality, life cycle support as well.

Air-to-surface weapons delivery continues to present a formidable challenge in the great complexity, flexibility, and variety of simulation required to meet our extensive mission requirements. This challenge is, of course, common to all the Services. Every aspect and breakthrough in emerging technology will continue to be brought to bear to improve our capability in this critical area.

As to how we use our simulators, I have highlighted our integrated system, building block, least cost approach in both design and application. In amplification, let me say that we have not wavered in our view of a supplemental, rather than substitution, role for simulators versus actual in-flight training. There is no substitute for hands-on, in-flight experience in preparing for operational and combat flying. In the system approach to aviation training, we impart knowledge in classroom lectures and individual computer aided learning techniques. Step by step with the classroom academics, we gain familiarity with systems equipment and develop skills, procedures, and correct habits in the simulators. We then refine the skills and gain the critical element of confidence through in-flight practice in the most realistic environment and scenarios we can create. This is the way we see the supplemental role of simulators in aviation system training.

The training benefit of simulators in this application derives from affordability and practicality. Let me make a critical point here about affordability. The trend in aircraft, mission, and threat complexity, demand for realism, and diminishing reaction times and margins for error are all driving training requirements, quantitatively and qualitatively, upward. More and better training means higher cost. Training and simulator costs are not going to decrease or, by any realistic projection, remain constant. The benefit of simulators then, is to reduce the inevitable cost growth in essential training.

We cannot afford the aircraft, training weapons, flying hours, facilities, supporting forces or time to train in the aircraft alone. Nor can we afford the hazards and loss of life and material inevitable in the actual practice of certain emergency procedures.

In safety alone, although assessment contains a subjective element, flight simulators are more than paying their way. Since we last testified before this committee, we have conducted a careful correlation between the introduction of A-7 simulators and accident data. The A-7 analysis established that the majority of the reduction in the A-7 accident rate was due reduced pilot error accidents in those flight environments simulated by A-7 simulators. Comparable aircraft, which were simulated only to a limited degree, suffered much higher pilot error accident rates in the same flight environments. The results of the Fleet Project Team analysis indicate that the A-7 simulator suite saved light attack aviation 25 A-7 aircraft and 7 aviators through the reduction of pilot error major accidents over a five year period. I must state that, while one may debate the exactness of the numbers, it is certain that lives and aircraft have been saved by the A-7 simulators. Subsequent to the A-7 analysis, our overall experience substantiates this finding. While almost every threat to safety in training and peacetime operation is constant or increasing, our accident rate in major high risk aircraft types continues to come down. No reasonable observer can doubt the contribution of simulators to this remarkable achievement.

In addition to affordability and safety considerations, actual electronic warfare, anti-air warfare, and anti-submarine warfare, and combat scenario inputs are effectively unavailable. We must make up for what we cannot afford, or otherwise cannot do in actual flight through continually increasing capability in our simulators. It will not be inexpensive, but it is, in my judgment, not just the least cost, but the only way to go.

I would like now to describe briefly four of our current major simulator acquisition programs, the SH-60B, AV-8B, F/A-18 and the T-45TS.

The SH-60B represents the first state of the art training system for a Navy helicopter. We will have two training squadrons; one at Naval Air Station, North Island, CA, where fleet training commenced in June 1984, and one at Naval Station, Mayport, FL, with a Ready for Training (RFT) date scheduled for March 1985. Each training site will be equipped with the following operator trainers; an Operational Flight Trainer (OFT), two Weapons Tactics Trainers (WTT) and a Weapons System Trainer (WST).

The OFT incorporates a 6 degree of freedom motion capability with a visual subsystem and provides training in flight maneuvers, takeoffs and landings, navigation, communications, malfunctions and emergency recovery procedures.

The WTT provides avionics subsystem training for the Tactical Officer and Sensor Operator in the operation of sensors and interpretation of sensor derived data in the prosecution of the ASW mission.

The most sophisticated trainer, the WST, incorporates a motion and visual system and has the capability to provide both flight training and tactical team full mission training.

The AV-8B training squadrons will be located at MCAS Cherry Point, NC, and MCAS Yuma, AZ. Each site will be equipped with an Aircrew Systems Trainers (AST), an OFT and a WTT. The first AST was delivered to MCAS Cherry Point, NC in September 1983. The AST has no motion or visual system. It was designed to train pilots in hands-on-throttle-and-stick operations, the head-up display, radar warning, and defensive electronic countermeasures.

The OFT will have a Computer Generated Imagery (CGI) visual with full color and day/dusk/night capability. It also will have buffet, G-seat/G-suit motion cueing. Its primary purpose is to train pilots in normal, degraded, and emergency operation, instrument procedures, and V/STOL and conventional takeoffs and landings. The first OFT is scheduled to be RFT at MCAS Cherry Point, NC, in March 1985.

The WTT will incorporate the same visual system with expanded horizontal and vertical fields of view for air combat maneuvering training. It will also provide training in weapons delivery, threat detection and analysis, and missile evasion. The first unit is scheduled to be ready for training at MCAS Cherry Point, NC, in August 1985. The MCAS Yuma, AZ, trainers are under contract and scheduled to be RFT during calendar year 1987.

The F/A-18 operator trainer program consists of a Part Task Trainer (PTT), and OFT and a WTT.

The PTT provides pilot proficiency training in hands-on-throttle-and-stick operations, head-up display, and missile shoot and tracking skills. One PTT has been conducting training at NAS Lemoore, CA since May 1982. A second is scheduled for delivery at NAS Cecil Field, FL in June 1985.

An OFT has been in place at NAS Lemoore, CA since July 1982 with a second unit scheduled for a June 1985 delivery. NAS Cecil Field, FL will receive two OFTs in January 1985 and April 1986, respectively. MCAS Beaufort, SC will receive an OFT in February 1986. The OFT is equipped with a CGI visual system and a "G" cueing system. It simulates the entire F/A-18 flight envelope and land/carrier operations, including day, dusk, and night field and carrier takeoffs and langings.

A WTT was accepted in January 1984 at NAS Lemoore, CA with additional units under contract for NAS Cecil Field, FL, MCAS El Toro, CA, and NAS Lemoore, CA. The WTT provides Air Combat Maneuvering training in 40 foot spherical projection domes with dual trainee/dual instructor stations with CGI visual displays. This device provides training in air-to-air missile, radar imagery, tactics, and aircraft normal and emergency systems operation.

The T-45TS trainer package, developed for the intermediate and advanced phases of the Naval Air Training Command strike pipeline, consists of ten Instrument Flight Trainers (IFT) and 22 OFTs. These devices will be sited at NAS Meridian, MI, NAS Chase Field, TX, and NAS Kingsville, TX with the initial RFT date in 1990.

The IFT includes a buffet system and provides, in addition to the full spectrum of instrument flight capability, standard training in takeoff, in-flight, and landing operations under both normal and emergency conditions.

The OFT will include a visual system with a G-seat/G-suit, buffet system and have the capability to train the student pilot in formation flying, field and carrier takeoffs and landing, tactical navigation, air-to-ground weapons delivery, air combat maneuvering, and normal and emergency procedures.

These two training devices, the T-45 trainer aircraft, and a computer assisted academic and flight support instructional system will be integrated and managed as a total training system by a computer-based Training Integration System.

Other emerging programs of significance include the JVX, F-14D, A-6E update, E-6A, and CV-Helo.

In the Navy's R&D for flight simulators, several of our major research programs are targeted to improve tactical air warfare training by pulling industry's efforts and state-of-the-art technology into our training systems. These efforts include improvements in simulator data base realism (at reduced cost), alternative image projection systems, and on-board systems for in-flight simulation/stimulation.

Existing computer-generated data base and display technologies appear to be approaching the practical limits of their capabilities, and are still lacking in needed realism. To satisfy this need for higher quality, real-world visual systems for tactical mission training, especially in air-to-ground weapons delivery, we are conducting research on digitized photographic data base systems.

To provide higher quality in-flight training, we are investigating the use of on-board or embedded simulators/stimulators to excite aircraft systems. These systems will permit tactical aircrews to conduct dynamic training scenarios at reduced cost

and in the absence of otherwise critical external support. Examples of this include air-to-air intercept and engagement, electronic warfare, and operator training for specialized sensors such as infrared and synthetic aperture radar.

The Laser-Air-To-Air-Gunnery-System, a substitute for towed target air-to-air gunnery, is now in limited production following a successful operational test and evaluation. First units will be delivered in December 1985 with deliveries continuing into 1987. This R&D product has been specified for the Navy's new training aircraft, the T-45TS.

Cooperative programs with other services are in work to develop and introduce new technology. Currently, no dynamic capability exists which allows/permits "seeing" real world projections of unfamiliar enroute terrrain, navigational check points, and approaches to targets for either training or operational planning. The Navy is participating in several joint programs to develop such capabilities.

A joint Memorandum of Understanding (MOU) is in work between NAVAIR and the Air Force Human Factors Research Laboratory (AFHRL) and DMA to pursue research in the use of high altitude overhead imagery to synthesize lower altitude perspective data bases which will include vertical terrain and man-made features. Navy and Air Force objectives are to incorporate this technology into operational flight and part task trainer to provide real-time, real-world omni-directional fly through data bases with high resolution projection of any desired geographical area.

A Memorandum of Agreement (MOA) under deveopment between NAVAIR and the Air Force (AFHRL), the Marine Corps, and the Joint Cruise Missile Program Office (JCMPO) will consolidate efforts to integrate computerized mission planning, computer generated target insertion and separate regional mapping techniques into digitized DMA data bases for low-level, high speed mission planning, post strike analysis, and command center intelligence. Specific Navy application for this effort will be at the newly established Naval Aviation Strike Warfare Center, Fallon, NV.

In summary, the bottom line is safety and operational readiness. Due to the factors I have mentioned, real minimum win-or-lose readiness objectives are not getting easier or cheaper to achieve. The total exploitation of all the simulator capability we can design and build is necessary to keep essential training effective and affordable.

Senator GOLDWATER. Thank you, Admiral.

A few years ago I was in Orlando, and I flew a simulator you were developing then that simulated shipboard landings. That is, you would be in flight, down there would be the carrier, and you would simulate a landing.

Did you ever complete that?

Admiral DUNLEAVY. Yes, sir. That is the one for the A-7, the NCLT, the night carrier landing system. The first was installed out at Lemoore, CA, back in the mid-seventies, and we really saw a significant reduction in accident rates. Now we have that in the F/A-18, and all of the carrier-based aircraft are now getting that visual system in order to have a shipboard landing capability with ship motion.

We have seen a significant reduction in the accident rates because of simulation. That really has been a big boom for all of us.

Senator GOLDWATER. You can put in ship motion now, pitching?

Admiral DUNLEAVY. Yes, sir, pitch, roll, and you heave.

Senator GOLDWATER. It took me four tries before I could hit the water. [General laughter.]

Admiral DUNLEAVY. Sir, I had the pleasure of escorting you to your first F-4 flight off the *Enterprise* with Gerry O'Rourke back in 1962. The deck was pitching that day.

Senator GOLDWATER. All right.

Now we have Major General Williams.

STATEMENT OF MAJ. GEN. HAROLD J.M. WILLIAMS, U.S. AIR FORCE, DIRECTOR OF OPERATIONAL REQUIREMENTS, DEPUTY CHIEF OF STAFF FOR RESEARCH, DEVELOPMENT, AND ACQUISITION, DEPARTMENT OF THE AIR FORCE

General WILLIAMS. Good morning, Mr. Chairman.

On behalf of the Air Force, I would like to thank you for this opportunity for us to tell you about what the Air Force is doing now with the simulator program. We are pleased to be able to join with the Army and the Navy in a joint effort, because we think that does represent the way it is happening.

We would like to be sure that we express to you as accurately as possible that the Air Force appreciates the value of simulation, and the contribution it makes to our overall training.

Certainly our overall goal is to provide the most effective training for our air crews as possible, least cost, and the overall training program includes more than simulators, certainly with flying, ground school and variety of training devices that some people label as simulators.

But most of all, we would like to focus on the flying simulation activities today. We think that it is important that we keep these simulators attuned to what the operators in the field need. It is certainly exciting about the opportunities that technology provides for us, and we look to the future for some real advantages in our simulation approaches.

At the same time, though, we feel that the advantages are to be best accrued if we are sure they are attuned to the field requirements. In order to do that, we would like to approach this from two aspects this morning, very briefly describe to you from the operational side of the house the plans and policy that we have in order to get the most out of the simulation effort, and then deal with the research, development, acquisition, which we think provides good checks and balances in an effort to provide the most effective training overall for the least cost.

I would like to ask Brigadier General Davidson now from Operations, Plans, and Policy to present that part, and then I will follow him with a more detailed discussion of the research, development, and acquisition.

STATEMENT OF BRIG. GEN. ALEXANDER K. DAVIDSON, U.S. AIR FORCE, DEPUTY DIRECTOR OF PLANS, DEPUTY CHIEF OF STAFF FOR PLANS AND OPERATIONS, DEPARTMENT OF THE AIR FORCE

General DAVIDSON. It is a pleasure to lead off the Air Force portion of the program this morning and talk to you about our Air Force simulator program.

AIR FORCE SIMULATOR PROGRAM

Simulators support 42 weapon systems.
592 major training devices.
1500 part task trainer.
3.0 billion in FY 85 budget (thru FY 90) for simulators.

The Air Force has a very large simulator program, the largest in the DOD, and probably the largest of its type anywhere in the

world. We have 42 major systems supported by this program, and when we total all of our devices together that incorporate some degree of simulation, we have nearly 2,100 such devices, and nearly 600 of those are what we would call large devices, and I will expand on that a little bit later.

We have approximately $2 billion invested in those devices right now, and between now and the end of fiscal year 1990 we will increase that by about one and a half times.

AIR FORCE SIMULATOR PROGRAM

The objectives of the Air Force simulator program are to: Provide effective initial training; and maintain and improve combat readiness.

Objectives achieved by simulator training: Safety-of-flight (general flying tasks); and warfighting.

The objectives of our program are pretty straightforward. The Air Force aims to use simulation wherever possible to provide the best and most cost effective training from the entry level right on up to the fully combat capable level, or even beyond.

We tend to focus our efforts in two general tasks, the first one being simply the basic task of teaching an air crew how to operate a specific aircraft or a system and how to fly it safety, with particular emphasis on the safety, and then the second one, the refining or the honing of the war fighting skills that the air crew needs to get maximum combat effectiveness out of the aircraft or the system.

AIR FORCE SIMULATOR POLICY

Concentrate simulator training on tasks that cannot be effectively trained in the aircraft: Safety-of-flight trainers; and warfighting trainers.

Use commercial training.

Discipline simulator modifications: Safety-of-flight changes in-line with aircraft mods; and block updates for all other mods.

Recognizing that the simulation has gotten to be very big business in the Air Force, this past year we took a close look at our policy for managing the simulator business, and made some changes to it, and this slide outlines some of the key features of that policy.

We aim our efforts at the kind of training jobs that have to be done but maybe too difficult or risky to do in the aircraft itself. I might give you some examples of those. They would be things like electronic combat countermeasure training, wherein if we did it with the real thing, we would tend to disrupt or jam civil communications or television, air-to-air engagement training that might exceed the limits of our ranges or our air space, Beyond visual range [BVR] type engagements, long range missile engagements, extended supersonic flight type of maneuvers that would simply exceed the air space we have available, and then, of course, the basic safety of flight, emergency or abnormal procedures that we would like the pilot to see, particularly things in the corners of the envelope, for example, that, before we had simulators, he may have only found out about when it was too late, and now we can expose him to that with a simulator and get a good feel for how the airplane actually handles before he sees it in the real airplane.

We are getting very interested in commercial training for a couple of reasons; first to ensure a more uniform product, and second, and probably more importantly, to free up military manpower for more important needs. We have got a number of examples of that, but some of the larger ones that have gotten more publicity are the very successful KC-10 contract training program being operated by American Airlines down at Barksdale AFB in Shreveport, LA.

And we recently put the E-3A AWACS program into a commercial training effort that is going to be conducted by Boeing, and very shortly there should be an announcement on the C-5A training program that will be a commercial contract.

As Admiral Dunleavy mentioned, there is a tendency in a lot of our new weapons systems for the airplane to be software intensive, and the avionics content continues to increase. We are seeing a phenomenon wherein the basic mechanical air frame will stay with us for a long period of time, but we can literally change the entire character or flavor of the aircraft by modifications to its avionic suite, and literally create a new aircraft.

That in turn creates problems in keeping our simulators in harmony with the aircraft itself, because we have found that if they get too far apart, we get what we call negative training, and the air crews are literally turned off by the simulator training, because they know it is not like the real airplane.

We have gotten very concerned about keeping that in G, and so we are focusing some of our efforts now on putting more discipline into the simulator updates and modifications. And we are interested in minimizing the amount of downtime in these training devices, and making the modifications more predictable, and hopefully gaining some management control over the cost and schedule of these.

We think we are having some pretty good success. The crux of our policy in this area focuses on doing the safety of flight mods concurrently when they are done in the airplane itself, but we are trying to group the other mods that are not safety and flight-related into blocks that will be done periodically, where we will do a total upgrade on a series of simulators.

FAMILY OF SIMULATORS

Cockpit Procedures Trainer [CPT].
Operational Flight Trainer [OFT].
Weapon System Trainer [WST].
Part Task Trainer [PTT].

We tend to group our simulators in four categories, and I will go over these just briefly with you to familiarize you with the terminology that we use, and General Williams will expand on that a bit in his briefing.

The first three are the larger types of trainers, and they are grouped in order of ascending sophistication. Of course, the cockpit procedures trainer sort of speaks for itself, focuses basically on the Cockpit environment, and teaches the air crew what all the bells and whistles are up there that they need to know about.

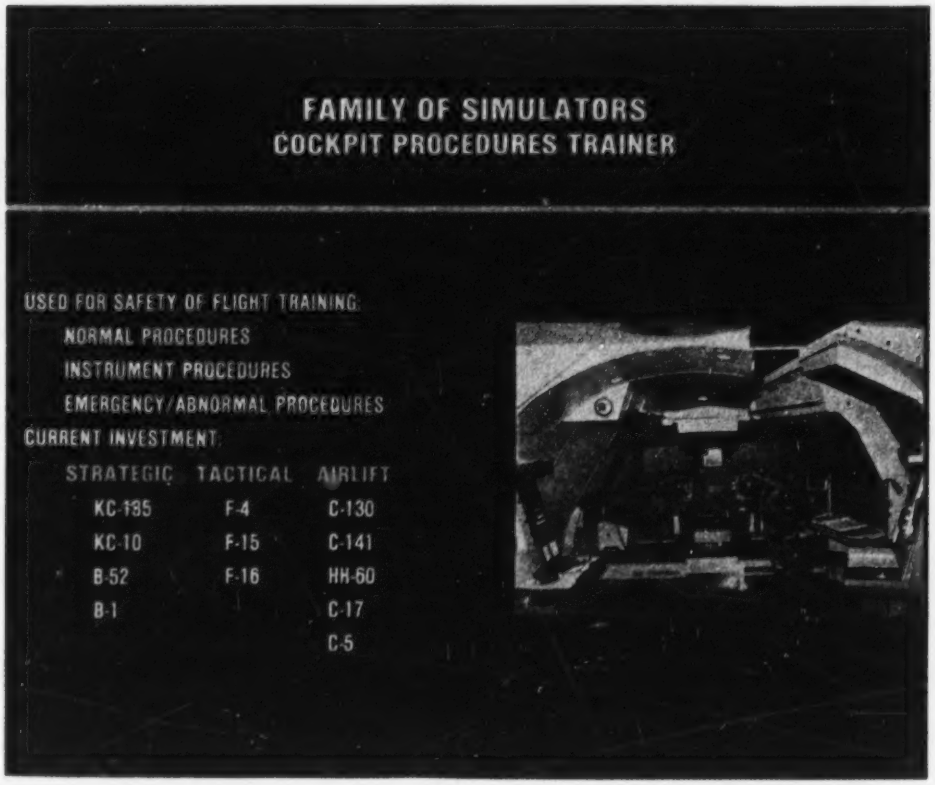
As we get into a little more sophistication and simulate more of the aircraft's capabilities and more of its systems, that is called an

operational flight trainer. The fullblown system with all crew positions emulated, and generally full visual and full motion systems, and total mission simulation capability is called the weapons system trainer or the WST.

And then there is another category that comprises a very large number of our devices, and those are called part task trainers. In days past they tended to be very simplistic devices, and accordingly somewhat less expensive.

They are still, relatively speaking, less expensive, but they are getting more sophisticated by virtue of the microprocessor explosion that we are experiencing these days, and we are finding that we can incorporate more and more capability and more training capability into literally a desktop device.

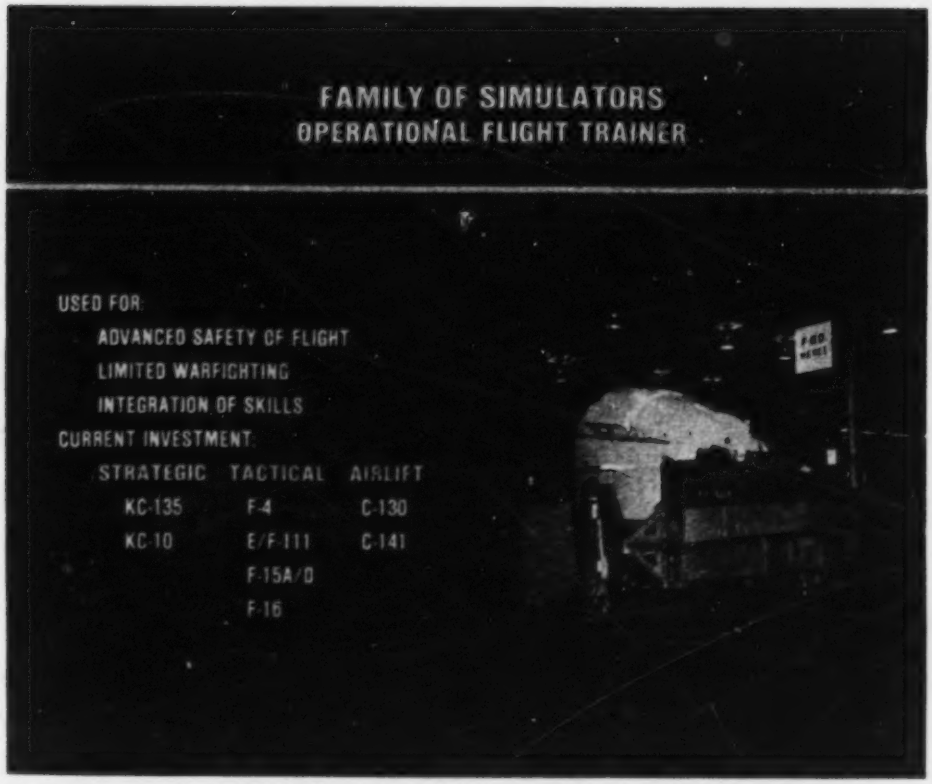
I will walk you through a quick look at some examples of these.



The cockpit procedures trainer, this happens to be one of the new C–130 cockpit procedures trainers located at Little Rock Air Force Base in Arkansas, pretty much state of the art, and represents the direction that CPT's are going.

They are moving into digital based devices with higher fidelity than the older units, and most of the new units, although they do not have motion and do not have a visual system, do have flight dynamics built into them so you can fly the aircraft with the cockpit procedures trainer. You can do instrument flight training on these kinds of units.

It is very useful. These are the various aircraft that we are using CPT's with. Some of these are in development. Some are in production. And some are already fully fielded.



Going up the scale into a little bit more elaborate system, this is an operational flight trainer located out at Cannon Air Force Base in Clovis, NM. This one is for an F–111D.

It does have some motion, a limited visual system, and it does have a capability to go beyond simulating the basic flight characteristics of the aircraft, and can do some limited mission training for the crew, although not to the extent that a complete weapons system trainer can do.

Senator GOLDWATER. Have you included the electronic F-111 in simulation?

General DAVIDSON. The EF-111, sir, General Williams is going to talk about a little bit in his briefing specifically.

General WILLIAMS. The answer is, yes, sir.

Senator GOLDWATER. Thank you.

General DAVIDSON. The weapons system trainer or WST is the most sophisticated of the larger trainers that we use, and this particular one is the B–52 WST. This one happens to be located out at Castle Air Force Base in California, a very sophisticated system with a full visual capability.

Digital land mass simulation capability for the radar can replicate the crew positions and crew duties of all of the crew members on a B–52, and it is all tied together with a very elaborate instructor or series of instructor stations on the outside, so they can make the training task more complicated and react to the individual progress of the specific crew members.

A very fine device. And you will notice they tend to be used for the larger airplanes that have multiple crew positions, although the F–15E will be an exception to that. A very important feature of these is that you can do a full mission rehearsal of something like a single integrated operational plan [SOP] cut mission from beginning to end, which would be simply impossible to do in almost any other situation.

Senator GOLDWATER. You say that is out at Castle. I flew a simulator some place that hooked up with a tanker. Where is that?

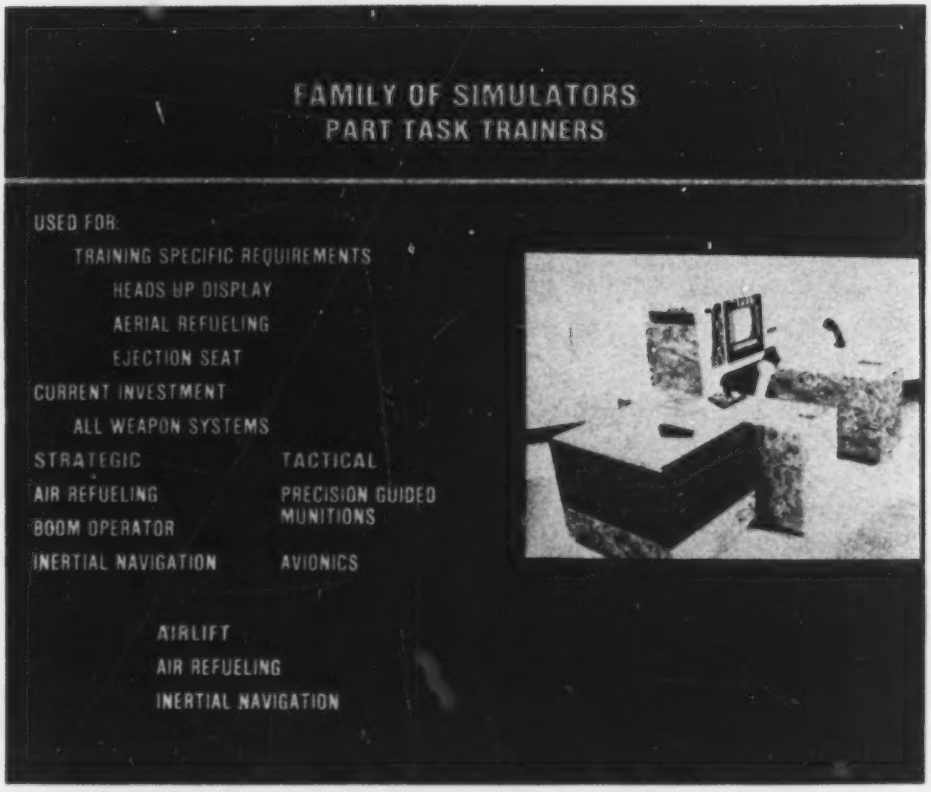
General DAVIDSON. There are a number of these. There is one at Griffith. There is one at Minot. And there are quite a number of them going in.

Senator GOLDWATER. This is not the only one that hooks up to tankers then?

General DAVIDSON. No, sir.

General WILLIAMS. And we even have some part task trainers where you can practice refueling basically alone but without any other type of device.

Senator GOLDWATER. Thank you.



General DAVIDSON. In rounding out the quick look, here is an example of a part task trainer. This particular one trains fighter crews in a stores management panel that happens to be common to a number of airplanes. This particular one is used on the F-4, on the F-111, on the F-15 and the F-16.

It is a relatively inexpensive device, microprocessor based, but it does one heck of a good job of training at a relatively low cost, and we are using these for a lot of different things.

One good example is a very inexpensive desk top simulator to train air crews in operating inertial navigation systems. As many folks are aware of our modern aircraft systems are built around an inertial platform that is used for a number of things in addition to basic navigation.

But the system is operated from a rather small control display unit that has an awful lot of pushbuttons on it, and it has a great deal of capability, but you have to know what you are doing, and

we have ample evidence that if you do not know what you are doing when you punch in the numbers you can have big problems.

Maybe we should have offered some of these to some other customers, and it might have been very useful in some cases, but that device that we use for the inertial training is really just a basic computer with some modified software, and it goes on the order of $3,000 of $5,000.

And it does a bangup job of training, and we are seeing more and more of those kinds of devices used, and as I indicated earlier, because of the increasing use of microchips and the expanded capability of those devices, we are seeing more punch put into a very small package in the part task trainer business.

Senator GOLDWATER. Let me ask you, does this include NAVSTAR and Omega?

General DAVIDSON. NAVSTAR—we do have a training device for Omega. NAVSTAR is coming along, and we do not yet have a training device for that, although what we may see when we get to NAVSTAR GPS installed in airplanes is a common control display unit that will be used, so it may well be that by modifying the software, we can use this kind of a device to train that as well.

Senator GOLDWATER. I remember when I flew that thing it was the ATB. Go ahead.

General DAVIDSON. At this point, sir, I would like to hand it back to Major General Williams, and he will give you the research and development look at our program.

General WILLIAMS. Senator, we would like to continue now by looking at something that I know you are concerned about, and that is the simulator cycle. We would like to divide our approach to that into two main parts.

SIMULATOR CYCLE

Weapon system (non specific): Basic research on simulator techniques.
Weapon system (specific):
Research and development: Prototype simulator development through ready for training.
Production: Simulators produced and accepted for training.
Operational use: Integrate into Air Force training program, and modify to maintain concurrency with aircraft.

We do basic research for simulation that is nonweapon specific. I do not want to give you the wrong impression that it does not have a very pointed purpose, but I am sure you appreciate the fact that there is a lot of commonality. Admiral Dunleavy already mentioned modularity in those types of opportunities, as did General Kenyon.

We look to that in our basic research to take advantage of emerging technologies in the software and those types of opportunities. We also, though, and this is where the most tangible products are produced, do basic research in the weapon system specifically.

There are three parts to that, the research and development phase, where we are trying to decide, as usual in R&D, what we are trying to do and what we need it for, then the production phase, and finally the operational use phase.

I need to emphasize also that it is very important to realize that simulators are not just for initial training. I know you appreciate

the value of recurring training. That continues for people with all levels of experience, and simulators play a very important role in that throughout the career of approval.

SIMULATOR CYCLE

R&D	Production	Operational
B–1		
F–15E		
T–46		
EF–111		
HH–60		
	F–16	F–16.
	F–15	F–15.
	KC–10	KC–10.
	B–52	B–52.
		KC–135.
		C–5.
		F–4.

As I mentioned, we have these three major areas in the simulator cycle, research and development programs which are shown and, production, and operation. It is important to realize also that with the program we may have programs in all cycles.

In some cases the F–16 would be, if we bring the F–16 to follow on, involved in this. Here you see the F–15E in development, the F–15 in production, and the F–15 that is currently in operation, so we have some weapons systems.

Specific simulators are involved in all three phases, research and development, production, and in operational use, of course, it would be under the modifications required to keep them current with the weapons systems in the field.

MAJOR AIRCRAFT TRAINING PROGRAMS

Major weapon system	Part task trainer	Cockpit procedures trainer	Operational flight trainer	Weapon system trainer
Strategic:				
B–1	X	X		X
B–52	X	X		X
KC–10	X	X	X	
KC–135	X	X	X	X
Tactical:				
F–4	X	X	X	
F–15	X	X	X	X
F–16	X	X	X	
F–111	X		X	
EF–111	X		x	
Airlift:				
C–17	X	X		X
C–130	X	X	X	X
C–141	X	X	X	
HH–60	X	X		X
Specialized:				
GBU–15	X			
C–5/C–141 air refuel	X			

This is just to give you a feel for the scope. I think you are familiar with our overall approach to strategic, tactical airlift training, devices as well as the specialized part task trainers that General Davidson mentioned such as the GBU-15 air-to-surface standoff munitions.

But across the top you see the different categories, part task trainer, cockpit procedures trainer, the operational flight trainer, and then the weapons system trainer as it increases in complexity.

And for each of the systems on the left, we have a scope of these types of systems, depending on what we need. In each and every case, we do not have one of every type, because we do not need it. It is not cost effective to do that.

But we are very sensitive to it, and I believe in each and every case we have at least a couple in each category.

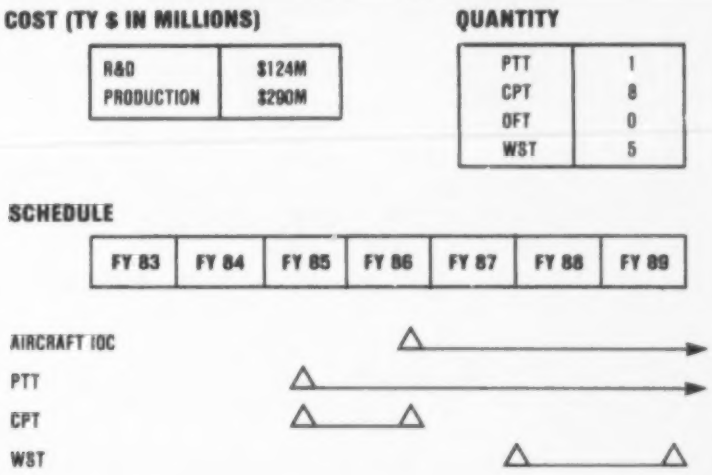
Of our major training system programs, I would like to look at the B-1, the C-5, the EF-111 that you asked about, the F-15, and then the GBU-15, and I will discuss each of those.

The B-1 will probably be our most sophisticated flight simulation, because we think we can get the most return on the investment there. Within the crew positions, as has already been mentioned, we can have an integral crew operating as the crew would in the air, using the flight offensive and defensive systems, and radar and electronic warfare with both a visual picture outside a six degrees of freedom motion base for as much realism as possible.

I think I can say without hesitation that we get a great return on the dollar for electronic countermeasure training. Within that arena, we are able to simulate much more closely, than we can afford on a range, the actual conditions that the electronic warfare officer or defensive systems operator would encounter were he to go into actual combat.

We say here, as was mentioned, the single integrated operational plan, which you are familiar with, the SAC emergency war order mission, and full crew coordination is possible. Full crew coordination is possible such that as they were to go through the target area, the electronic warfare officer may see a missile threat, the offensive systems operator is looking for the target on radar, looking for those returns, and the pilot and copilot may be encountering visual attack from aircraft or other threats that are realistic to the total environment he would find in combat.

B-1B TRAINING SYSTEM



These are R&D numbers, $124 million. This is the production of the simulator for $290 million. The quantity shown up on the right is broken down. We have broken out the quantity in each case, and you will see this format again, Senator.

We have one part task trainer, and eight cockpit procedures trainers, and five weapons systems trainers that are being programmed for the B-1 system. Down across the bottom you will see the aircraft initial operating capability.

That means one squadron, and then the part task trainer and cockpit procedures trainer and the weapons systems trainers coming in at the beginning of 1985 for the part task trainer and the cockpit procedures trainer preceding the arrival of the aircraft.

Ideally, we would like to see the weapons system trainer arrive prior to the aircraft, but due to the fact that the weapons system trainer is the most complex and the most sophisticated, in effect it becomes a weapons system design and production program in itself.

That is good, in that when we do get it, it really gives us the opportunity to get the kind of training that I mentioned earlier, with as much realism as possible, but it is bad in that it takes more to develop. But we do feel that with the combination of the part task trainer which is designed to do the specific training procedures, as General Davidson described, and the cockpit procedures trainer, that that covers the safety of flight, are those items most essential to provide the air crew prior to the arrival of the first aircraft.

So, we think we have a good balance here, capitalizing upon the technology as best we can, while still affording what is critical prior to the aircrew receiving the aircraft.

The EF-111 you asked about is very important in this case. It is possible to use the technology to provide the crews with a good range of training for the electronic warfare for which the EF-111 is specifically designed.

It gives both the pilot and the EWO stations full electronic warfare and, radar simulation. It also provides motion cues through a g-suit and the g-seat. We think that it is realistic, and from takeoff to landing we can provide the full range of training requirements that the crew needs.

There is a caveat that I guess I should add, and that is, it is not quite like flying the airplane with the full scope of flying activities, but in terms of electronic warfare, we think it is the best thing going.

EF-111 OPERATIONAL FLIGHT TRAINER

COST (TY $ IN MILLIONS)

R&D	$54M
PRODUCTION	$24M

QUANTITY

PTT	0
CPT	0
OFT	2
WST	0

SCHEDULE

FY 83	FY 84	FY 85	FY 86	FY 87	FY 88	FY 89

AIRCRAFT IOC: △

OFT △——△

Once again, the EF-111 shown in same format we had for the B-1, that shows the amount of money for research and development and production, and in this case we are buying two operational flight trainers. The aircraft is already past its IOC, its initial operating capability. We will get the first operational flight trainer in fiscal year 1986, and the second one in 1987.

In this case we had to proceed to the operational flight trainer to be sure we had the most recent requirements integrated into the simulation techniques that we had actually installed in the aircraft.

I should add as a footnote also that the modifications to the trainers will continue as the systems within the aircraft change.

The F-15 operational flight trainer for the pilot provides the full range of air-to-air radar simulation and an electronic warfare simulation with that. He can get the radar intercept training, and the threat recognition from the electronic warfare signals.

F-15 OPERATIONAL FLIGHT TRAINER

COST (TY $ IN MILLIONS)

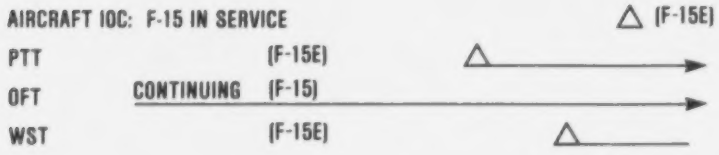
R&D	$49M
PRODUCTION	$343M

QUANTITY

PTT	1
CPT	
OFT	14
WST	6

SCHEDULE

FY 83	FY 84	FY 85	FY 86	FY 87	FY 88	FY 89



We are going to have 1 part task trainer, 14 operational flight trainers, and 6 weapons service trainers for the F-15, to include the F-15E, and we are able to capitalize more on the weapons systems trainer for the F-15E thanfor the F-15, because the range of electronic and avionic threats that the crew has to, or the pilot has to deal with is a lot easier to integrate the radar bombing capabilities and the electronic systems into a good operational flight trainer weapons systems trainer than it is the air-to-air visual or air-to-air combat mission, and that is reflected in our plans for the F-15E, which as you know, sir, is primarily air-to-ground strike mission.

The C-5A and C-5B is a little different, and I will try to explain that. We are looking at capitalizing on the contractor training approach that permits the contractor to do a lot of the tradeoffs. These are the same tradeoffs which the Air Force becomes encumbered with. The contractor can, therefore, speed up our capability to get that system into the field.

He will look at the curriculum. He will refurbish those systems we have in the field already that need refurbishing, and we may add some additional simulators as required. We think that in this case again we are able to benefit from an integrated crew training approach to include air refueling and even cargo loading for training packages.

I am sure you will appreciate that a lot of that can be done within mockups, simulators, in other words, much more efficiently than it can on an actual airplane.

C-5 TRAINING SYSTEM

COST (TY $ IN MILLIONS)

R&D	0
PRODUCTION	$202M

QUANTITY

PTT	0
CPT	4
OFT	0
WST	7

SCHEDULE

	FY 83	FY 84	FY 85	FY 86	FY 87	FY 88	FY 89
AIRCRAFT IOC				△			
PARTIAL SYSTEM OPERATIONAL				△			
FULL SYSTEM OPERATIONAL					△		

Here you can see the C-5 in the same format. We plan to put into production, $202 million. We do not have to do the research and development. The contractor is doing that, and that is more for the growth than it is the basic research and development. We will have four cockpit procedures trainers and seven weapons systems trainers.

The C-5B has an IOC in fiscal year 1986, and then we will have part of these in the field in 1986 with the full system simulated in fiscal year 1987.

This was touched on earlier, but I would like to expand on it just a bit to try to give you an example. We are looking across the board for opportunities to provide better training in simulators. This is the GBU-15, and it is a part task trainer.

It will be primarily for the F-15E, the F-4E, and the F-111F. Of course, we can expand that if we put the GBU-15 onto other aircraft. Right now it is programmed for just those three systems. It does permit us to simulate target acquisition as well as weapons employment from release to impact.

I am sure you can appreciate the cost if we tried to do this on a range, not only for the munitions, but I am sure you know with your experience the cost of range time to get all of the safety procedures and all of the personnel out there to do the data recording.

We could do all of that. We could do all of that very efficiently in a part task trainer. So we think that is an excellent example of expanding the scope of the traditional view toward simulators.

GBU-15 PART TASK TRAINER

COST (TY $ IN MILLIONS)

R&D	$16M
PRODUCTION	$21M

QUANTITY

PTT	6
CPT	0
OFT	0
WST	0

SCHEDULE

FY 83	FY 84	FY 85	FY 86	FY 87	FY 88	FY 89

WEAPON SYSTEM IN PRODUCTION (1982)

PTT △——△

We plan to have six of these part task trainers. The first one will arrive in 1987. The last one will arrive at the first part of 1989.

Overall, our R&D objectives are to pursue the new technologies and adapt them to the generic development such as the visual sensor, motion, and the operator station.

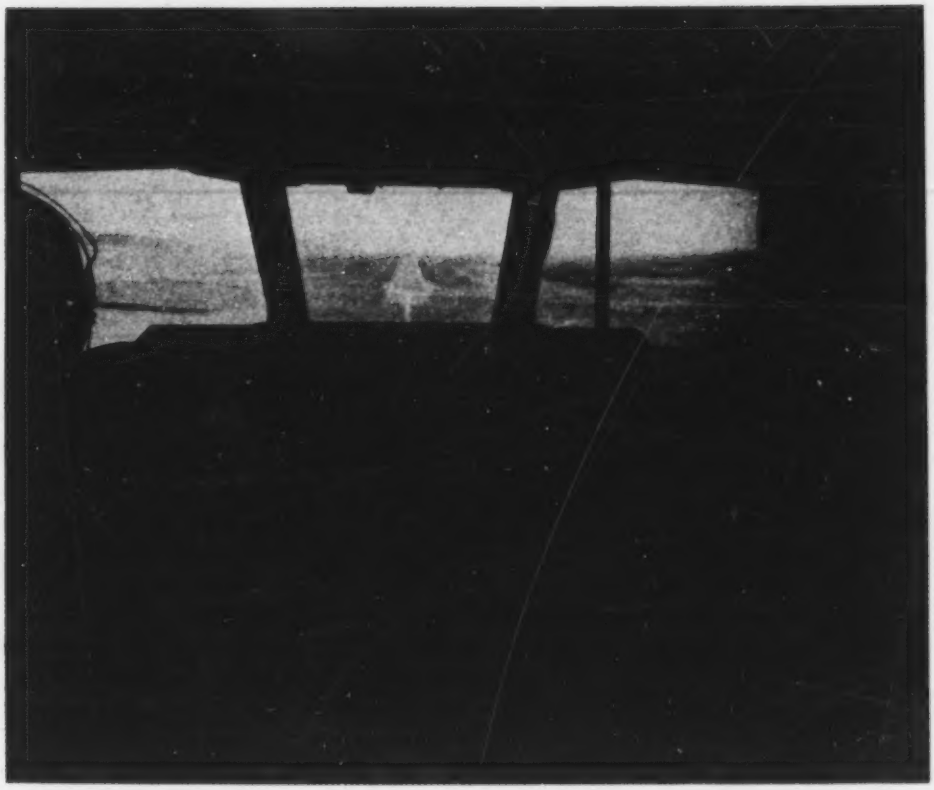
An integral part to an effective simulator program is the fact that the guy who is doing the simulating for the crew member is able to do what he needs to do, and that is why we concentrate on the instructor and the operator station. We can do effectiveness evaluations, and I will talk more about that in a moment, and there is interservice cooperation, as we mentioned earlier, but I will comment on that also.

In generic development, we are looking at visual simulation, and I believe you have seen some actual cases where we can simulate formation flying, and even in some cases some prototypes of air-to-air missiles, and see if you can go out and strike the targets.

Concerning sensors, we are looking at radar land mass. We can put any area of the world into this radar land mass, and then the pilot and the radar navigator in this case, if it is a several crew position aircraft, can look at his radar display and get a very realistic look as best we can determine as to what his actual target area, anywhere in the world, would look like.

Motion provides us at very little cost the capability to give us the feel that is important also to flight, and I have already mentioned the instructor operator station.

I would like to pause for a moment and say once again that this has to be stepped up in order to assure that the crew members who are being trained are able to receive the right inputs in the overall simulation at the right time in order to get the best training.



This shows a picture just looking out the window of a visual on a weapons systems trainer for the B–52.

I think this is an interesting view here, if I might pause for a moment, Senator, to walk you through this real quickly. This is early seventies. General Electric looked at simulation. It is OK. It is certainly representative of that time of progress, but it is far from what we felt we needed.

This is a look here from Singer in the midseventies. This is on the F–111 simulation, where instead of an upside down tree we at least now have the tree right side up. In order to protect General Electric and not give you the wrong impression, they, too, stepped forward here recently with this approach, which is computer generated image. In effect it gets away from the edges technology here, which is something like 2,500 edges in the early seventies, moving to 8,000, and very rapidly with this approach we were saturating our computer. So in this case they would have to have 800,000 edges. Instead of doing that, they took a more innovative approach, and just captured the image.

You could say it was a photograph, what they captured, and they would just reproject the image or the photograph rather than trying to build individual images and get a much more realistic effect. We think that has some real potential for us.

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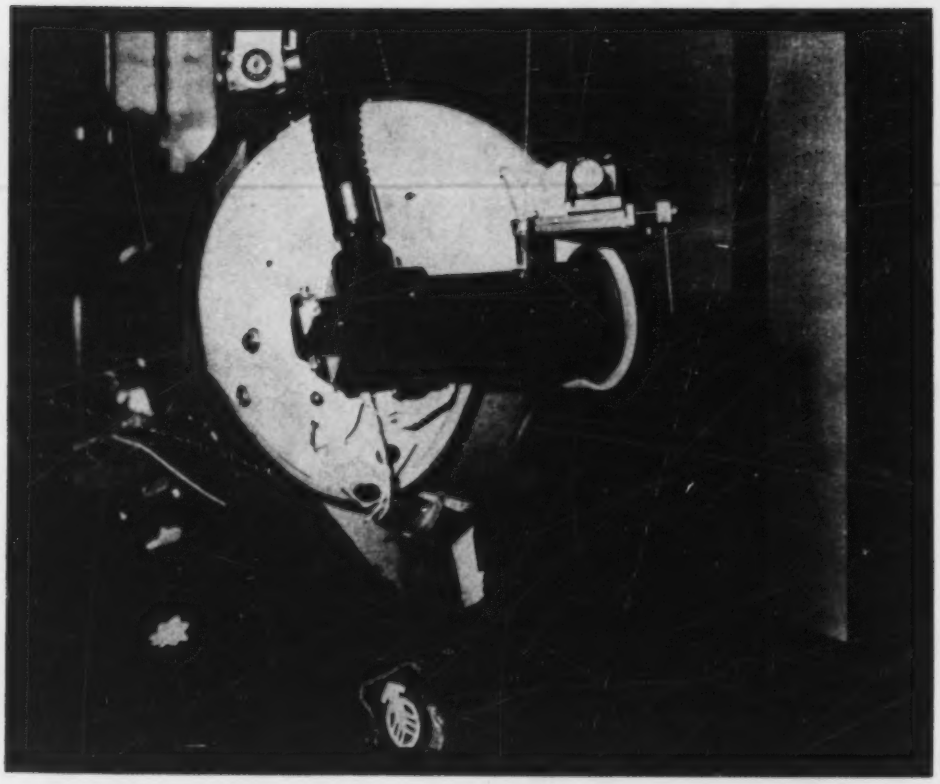

One other idea that we are investigating, we are not sure how this is going to turn out yet, is rather than try to put it across the entire field of view outside the windows of the cockpit, which is very large and does give us problems from the technology standpoint, we may look at putting it on the cockpit visor, so to speak, mounted on the helmet of the crew member. For everything that he saw, he would see a very realistic picture, but yet the requirements technically to do that are considerably reduced. We are not sure that is going to work yet, but we are investigating that as an opportunity.

INTERSERVICE COOPERATION

Standard DOD Data Base Transformation Program.
Simulator modularity.
Joint logistics commanders: Joint Technical Cooperating Group on Simulators and Training Devices.
Eye slaved display integration and test.
ADA, standard DOD computer programming language.
R&D Coordinating Conference and subgroups.

Interservice cooperation, that has been, mentioned by Army and Navy colleagues—I will not dwell on it too long, except to say we understand it, we appreciate that, and we are working hard to be sure we capitalized on it.

Modularity, as has been mentioned, the standard DOD data base has already been discussed, and the joint logistics commanders I do

not believe was mentioned yet, so I might pause for a moment there.

The joint technical coordinating group on simulators and training devices does meet under the auspices of the four logistics forces of the services to be sure that we are looking at technology for the simulators. As you know, the logistics time and time again is the long pole of the tent. In this case the JLC, the Joint Logistics Commanders, are working toward that to try to resolve those problems early on.

As I mentioned, the Eye Slaved display integration and test, the edit has been mentioned, and we do have a number of coordinating conferences and subgroups, and in fact I will take credit for one today, since we are discussing this together.

Finally, I guess I can summarize and say I guess from the Air Force standpoint we approach simulation from two fundamental aspects. One is safety of flight, to be sure that we provide our crews on the ground early on, and then throughout their life as a crew member, with the most effective training possible to reduce the hazards that are common to flight.

Second, though, and I think this is the area that has the greatest potential for something in the future that we have not done in the past, and that is to increase our readiness through more realistic training by capitalizing on emerging technologies and integrating all of that into our overall simulation programs.

We appreciate the opportunity to address this, and we will submit a statement for the record, and we will be happy to entertain any questions.

[The prepared statement of General Williams follows:]

PREPARED STATEMENT OF MAJ. GEN. HAROLD J.M. WILLIAMS, DIRECTOR OF OPERATIONAL REQUIREMENTS, DEPUTY CHIEF OF STAFF FOR RESEARCH, DEVELOPMENT AND ACQUISITION, USAF, ACCOMPANIED BY BRIG. GEN. ALEXANDER K. DAVIDSON, DEPUTY DIRECTOR OF PLANS, DEPUTY CHIEF OF STAFF FOR PLANS AND OPERATIONS, USAF

Mr. Chairman and members of the committee, I appreciate the opportunity afforded the Air Force, through this hearing and your interest, to present the Air Force Aircrew Training System program. During the last hearing on this subject, we discussed the Air Force philosophy and objectives of using flight simulation to increase aircrew readiness. Since four years have elapsed, an update is in order.

Air Force policy states that simulators complement flying time. We have determined that simulator training, applied as part of a training system, can significantly increase aircrew combat readiness. During the mid and late seventies, we experienced gradual erosion of the Air Force flying hour program. This reduced the flying time available below the point required to maintain combat readiness. For example, the average F-4 pilot monthly flying time decreased steadily from 20 hours in 1972 to a low of 14 hours in 1980. Today, we have programmed 16.8 hours for the typical F-4 pilot, and 18.2 hours for the F-16. As an example of how our policy has affected the training system, we have reversed this trend and our current planning reflects the minimum profile to regain and maintain safe and effective combat readiness. In addition, we have been able to introduce new and improved simulators into the inventory to complement our flying hour program. We have found that specific levels of aircraft training are absolutely necessary to mature our young aircrew members and simulation can best be used to make each flying hour more effective and productive. Given this combination of increased flying time and development of improved training systems, we have been able to achieve the lowest accident rate in Air Force history, and our highest level of combat readiness since Viet Nam.

Based on the Air Force policy that simulators complement flying time, we have established and are meeting the following simulator objectives. First, simulators are used to train safety-of-flight tasks that require repetition or flight conditions that

are difficult or not prudent to achieve in the aircraft. Normal, emergency, and instrument procedures as well as crew coordination are included in this category and are very well suited to simulator training. Safety-of-flight trainers are a core requirement for aircraft training programs and must be ready for training at each base prior to the delivery of the first operational aircraft.

Second, simulators are used, where possible, to train those warfighting tasks that cannot be easily trained in the aircraft because of equipment, range, or airspace limitations. For example, only in the simulator can an F-16 pilot practice all of the required electronic warfare (EW) skills which he will use in combat. In fact, in some of our older systems which have limited training capability, the pilot is never able to practice the full spectrum of the interactive EW and other skills he will need in combat situations. Air Force weapon systems which have these capabilities can train warfighting skills in either a part task mode such as radar operation, electronic warfare and aerial refueling, or in a fully integrated, mission rehearsal mode for individiual practice and crew coordination. Training programs may require both part task and rehearsal type simulators. However, we will ensure that the more capable mission rehearsal simulators are used primarily for teaching warfighting skills. This will minimize the number of these higher cost and more sophisticated devices.

Air Force policy encourages the use of commercially available training programs when they can be cost effectively adapted to Air Force use. The KC-10 training program is a successful example of a contractor provided and guaranteed aircrew training program which meets proficiency levels specified by the Air Force. If a crew member fails the Air Force administered simulator evaluation, the contractor provides additional training at no cost to the government. Although this approach has proven successful on the KC-10 and is being pursued for the C-5B and E-3A, it cannot be extrapolated for all combat mission training. We are, however, working to identify the missions to which this approach can effectively be applied.

In order to implement our policy for simulators, we must be able to determine how well each simulator does its job. The following are some of the ways we measure simulator effectiveness.

The first is improved combat readiness. Studies by the Air Force Human Resources Laboratory (AFHRL) show a very positive improvement for initial combat skill acquisition following simulator training. Even experienced A-10 pilots produced better scores on the gunnery range following combat skills training in the Advanced Simulator for Pilot Training (ASPT).

The second includes systems like the automated performance measurement system which was developed by AFHRL and is installed in the C-5 simulator at Altus AFB, OK. This system gives "real time" evaluation of pilot performance, allowing adaptive learning to occur. This allows students to progress at their own pace to increasingly complex tasks as their proficiency in basic tasks is achieved. This will provide a more accurate measure of the actual transfer of training from the simulator to the aircraft.

A lower accident rate can be partially attributed to emergency and high risk training in the simulator. It is neither practical nor prudent to place and sustain an aircrew member and aircraft, in the airborne environment, into a simulated emergency situation which would result in egress or crash conditions. In the simulator, however, we can do this as often as required to obtain prompt and proper reaction to the emergency without risk or loss of the aircrew or aircraft. This use of today's more advanced and realistic simulators has been a positive step in reducing mishaps in the Air Force.

Increased crew coordination for aircrew members in the mission rehearsal environment has become an important measure. One of the most effective areas for simulator instruction, crew coordination is one of the critical factors affecting mission success. The means to integrate the extensive array of tasks imposed on crewmembers in a critical real time environment, such as penetrating enemy defenses, cruise missile training, or low level penetration in weather, does not exist except in the simulator or the combat situation. Slight miscalculations, errors in judgment, or slow responses could cause mission failure.

As simulators have come into greater use, the prospect for extension of airframe life has been an additional benefit. The aircrew now begins inflight training with strong procedural knowledge and a feel for how the aircraft performs during normal and emergency situations. The simulator trained pilot is less likely to overstress an airframe than an individual without the same training. Less abuse definitely equates to extended airframe life.

Similarly, the development of tactics in the simulator is important. These high risk maneuvers can be developed and tested in the simulator. Once the best tactic is

developed, it can be practiced by all pilots prior to inflight evaluation. This ensures that airborne flying emphasizes higher level skills rather than introductory learning tasks.

Simulators have demonstrated their usefulness in preparing aircrews for combat exercises such as Red Flag. These aircrews are better able to penetrate enemy defenses and put bombs on target. This ability, to do it right the first time, could well mean the difference between success and failure in the combat environment. This, in effect, may reduce the sorties required to kill a specific target. Additionally, the peacetime use of simulators for maintaining weapons delivery proficiency where no training munitions exist, or are extremely expensive, as in the case of precision guided munitions, holds the potential for tremendous economic savings without affecting readiness.

With the proper training program consisting of enough flying hours and the proper kinds of simulators, we will have more proficient aircrew members. Under wartime conditions those crew members will have a lower airframe and aircrew loss rate. This is an economy that the Air Force cannot afford to pass up.

We are placing more emphasis on research and development activities in training effectiveness. Among our projects are integrated perceptual information for designers, simulator instructional features, and handling qualities. We anticipate that the results of these projects will be complete in time to influence the design of the Advanced Tactical Fighter training system which will start development in 1989.

The Air Force continues to improve the management of our flight simulator programs. First, we feel significant economies can be achieved by standardizing designs and by sharing joint developments with other Services. To this end, the Joint Logistics Commanders (JLC) chartered a Joint Technical Coordinating Group on Simulators and Training Devices (JTCG–STD). For example, the Air Force is lead on the development of a common DOD data base/standard transformation program applying Defense Mapping Agency data for use in visual, radar, and sensor simulation. This effort, which will develop a program to be provided as Government Furnished Equipment (GFE), will reduce the proliferation of unique programs, and reduce development and life cycle costs. We have also activated the JTCG–STD Visual Subgroup to evaluate the emerging technologies in advanced simulator visual systems. They will use standard evaluation criteria to compare systems on a technical, cost, and training effectiveness basis. Another project which may lead to joint activities with the other services is the standard modular simulator design concept. This project is a new design concept which attempts to capitalize on commonality across simulator programs by developing a modular design allowing modules to be combined into a training device with predictable performance. The objectives of the project are to reduce development time, reduce development and support costs, and to increase the simulator competitive base.

Secondly, we are investigating the potential cost savings of using commercial practices and logistics support. Contractor support will be required for most Air Force simulator programs due to phasing out the military simulator technician career field.

Thirdly, we are programming funds for new weapon systems to ensure that an appropriate aircrew training system is fielded at its needed date. Safety-of-flight capability trainers such as cockpit procedures trainers will be delivered prior to delivery of the first operational aircraft. Trainers teaching leading warfighting skills will be delivered at the initial operational capability of the weapon system unless WST complexity forces a longer development time. We intend to start development of the aircrew training system upon successful Critical Design Review of the new weapon systems. We expect this to alleviate past problems caused by lack of training system when the weapon system is initially fielded.

Complementing our initiatives on concurrency is the training requirements definition analysis on future training systems. This analysis defines the total training requirement for a system prior to hardware development. Our goal is to select the complement of trainers that provides the best training.

Other recent Air Force initiatives include reemphasizing Air Force policy and updating training equipment regulations to keep training equipment updated to current aircraft configuration. We have developed an overview document that addresses the management and utilization of training devices from a life cycle perspective. We have instituted a program similar to one used by the Federal Aviation Agency. Our program is called Simulator Certification, or SIMCERT, and is a method for the user to annually certify and periodically test each simulator to ensure the device meets training requirements.

Turning to the RDT&E program, the Air Force continues to strongly support its Research and Development program as the basis for improving training effective-

ness. During FY 1985, the Air Force is investing approximately $43 million dollars in its simulator R&D program.

Of primary concern to the Air Force is the development of tactical visual systems for the front-line fighter aircraft. As you are well aware, the Air Force embarked on a challenging development in the late 1970's to develop a visual system, known as the Tactical Combat Trainer (TCT) program, that would meet the needs of the A-10, F-15, and F-16 aircraft in both the air-to-air and air-to-ground roles. Because of technology limitations, this effort experienced considerable cost growth and schedule overruns and was terminated in 1980. Since then development activity has continued on mosaic display techniques, computer image generations (CIG), and the projected area-of-interest display. Far term development includes investigation of helmet mounted visual displays.

The Advanced Visual Technology System (AVTS), which will use both a mosaic display and dome display with its R&D CIG system, is being developed at the Human Resources Laboratory at Williams AFB, Arizona, under our Advanced Simulator Technology program.

The AVTS CIG system will be installed on the Advanced Simulator for Pilot Training (ASPT) and will provide a much more complex and highly detailed visual image which will be used to investigate combat mission training in low level flight and hostile threat environments.

To continue development of area-of-interest displays, which is a higher resolution scene inset into the wide field of view visual system, the Air Force completed development of a helmet mounted occulometer. This is a sensing device to track exact eye position. Experiments have shown that a five degree field of view of very high resolution can be slaved to the eye. When viewed against low resolution background, detailed, high resolution imagery appears to be a continuous scene because servos move the five degree field of view fast enough to track eye movement.

Based on this technology, residual equipment from the unsuccessful TCT effort is being used to complete engineering development of a limited visual display, the helmet mounted sensing system, and the projectors. Engineering and subjective pilot evaluation of the high resolution area-of-interest inset required for weapons delivery training will be accomplished by the end of FY 1985. This is a joint development and evaluation program with both the Navy and contractors through independent research and development efforts. Results obtained from this evaluation will be applied to the AVTS and follow-on tactical visual systems.

The Combat Mission Trainer (CMT) will combine a helmet-mounted display for the visual system with parallel processing microcomputers for the basic simulation equations. This technology will take longer to develop than the Advanced Visual Technology System, but it promises great advantages in terms of lower system complexity, lower system cost, and transportability.

Proceeding to other developments, another major project will develop an advanced R&D visual/sensor simulation system based upon the development of two simulator subcomponents. One subcomponent is an emerging technology using a non-edge based CIG system to develop objects and extremely complex visual scenes (such as display of a tree with near photographic quality). The non-edge CIG scenes do not have the cartoonish appearance typical of current edge-type systems. A second R&D simulator subcomponent will involve the combination of the non-edge CIG and other digital image generation systems with videodisc technology, which is used to record either digital or real life images, for research investigations of advanced simulations of airborne sensors for radar landmass, low light level television (LLLTV), forward looking infrared (FLIR) imagery, and other types of visual imagery. With the increasing complexity and capability of aircraft sensor systems, simulator training with sensor systems has become increasingly important.

Further, we are evaluating advanced radar systems simulation techniques which could apply to the synthetic aperture radar system being procured. We are also studying the instructor operator station features actually used by the field instructors which will provide the first step toward developing a modular, generic instructor operation station. We are applying the Product Performance Feedback System (PPFS) to simulators. This is an improved maintenance data collection system currently under early development by AFLC. Additional Reliability and Maintainability initiatives include investigations into VHSIC, ADA, and simulated flight instruments. The simulator for Air-to-Air Combat (SAAC), at Luke AFB, AZ, is being modified in FY 1985/87 to an F-15 and F-16 cockpit configuration to provide air-to-air combat training and allow more extensive tactics development for these front line aircraft. All of these future efforts as well as those currently ongoing are directed toward the improvement of training effectiveness or the reduction of simulator costs.

The Air Force has programs in various stages of acquisition. We will now discuss each of these.

C-5/C-141 Aerial Refueling Part Task Trainer

The first of these is the C-5/C-141 Aerial Refueling Part Task Trainer (ARPTT) program which provides for the acquisition of a single purpose, state of the art device. This application of an aerial refueling trainer is a spinoff from the earlier development of the prototype B-52 ARPTT. A common cockpit will be provided to train C-5 and C-141 pilots refueling from either KC-135 or KC-10 tankers. The visual system will provide the required cues for the refueling task, based in large part, on AFHRL's research in this area. A total of seven trainers will be acquired at a cost of $53 million, one for each strategic airlift wing.

ARPTT SCHEDULE MILESTONES

Contract: August 1983.
Production Contract: 2nd Qtr FY 1985.
Ready for Training (RFT) No. 1: 4th Qtr FY 1986.
RFT No. 7: 3rd Qtr FY 1987.
Aircraft Initial Operating Capability (A/C IOC): In Service.

EF-111A Operational Flight Trainer

The EF-111A Operational Flight Trainer (OFT) fills a significant training void in fielding a fully operational EF-111A Tactical Jamming System (TJS). Without the EF-111 simulator, there is no acceptable way to train EF-111A electronic warfare officers and pilots in the complex electronic warfare environment. The OFT will provide a training capability to fully task load crewmembers to achieve and maintain combat crew readiness. Two OFTs are being procured at a cost of $78 million.

EF-111 OFT SCHEDULE MILESTONES

Contract: July 1982.
Production Contract Option: 1st Qtr FY 1985.
RFT NO. 1: 2nd Qtr FY 1986.
RFT NO. 2: 2nd Qtr FY 1987.
A/C IOC: December 1983.

F-15 Operational Flight Trainer and F-15E Weapon System Trainer

Production of the F-15 Operational Flight Trainer (OFT) continues to support increased aircraft buys. Training is provided in air-to-air intercepts, weapons delivery and electronic warfare. Nine OFTs are currently operational. The six F-15E Weapon System Trainers will provide full mission training for both the pilot and the weapon system operator. Total cost of the program is $392 million.

F-15 OFT SCHEDULE MILESTONES

Contract: May 1973.
RFT No. 1: December 1976.
RFT No. 10: October 1984.
RFT No. 12: October 1986.
A/C IOC: June 1976.

F-16 Operational Flight Trainer

The F-16 simulator production continues. This device provides training in normal, instrument, and emergency system operation. Scenarios include take-off, landing, all weather operations, limited weapons delivery, radar target acquisition, and attack. A playback capability shows students how their procedures can be improved. An electronic warfare simulation has been integrated with the OFT. It provides a full range of radar threats to be encountered by the F-16. A third feature, also procured separately is the Digital Radar Landmass Simulator (DRLMS), an improved air-to-surface radar simulator, which provides realistic training in air-to-ground weapons delivery and radar navigation. The pilot will be able to see near-real world radar returns of man-made and topographical features. A night visual system with a limited field of view is available at the training bases. The Air Force is continuing with an aggressive update program to maintain concurrency with the aircraft. Total cost is $1.108 billion.

F-16 OFT SCHEDULE MILESTONES

RFT OFT No. 1: March 1982.
RFT EWTD: July 1982.
RFT DRLMS: September 1984.
A/C IOC: October 1980.

B-1B Weapon System Trainer

The B-1B simulator program includes five Weapons System Trainers (WSTs), one Mission Trainer (MT) for the offensive/defensive station, eight crew procedures trainers (including the engineering research simulators), and a Software Support Center. The WST will provide the necessary interaction and crew coordination training for the SAC Emergency War Order (EWO) Mission. The WSTs will simulate the instrument performance, various visual presentations, and aircraft navigation. The acquisition strategy carried dual competition through Preliminary Design Review (PDR) (Phase I). A single contractor will be selected to complete the full-scale development and production programs (Phase II). This strategy lowers risk prior to hardware commitments, improves aircraft simulator concurrency and sustains competition as long as reasonably possible. Total cost is $428 million.

B-1 WST SCHEDULE MILESTONES

Contract Award
Phase I: August 1983.
Phase II: October 1984.
WST ±1 Ready for Training (RFT): 1st Qtr FY 1988.
Crew Procedures Trainer RFT: 3rd Qr FY 1986.
Mission Trainer ±1 RFT: 1st Qtr FY 1988.
Aircraft IOC: 4th Qtr FY 1986.

KC-10 Mission Simulator

The KC-10 training program was the first attempt to fuly use existing commercial facilities and training programs by procuring training as a system, i.e., contracting for delivery of a fully trained crew. American Airlines adapted their commercial training process for the DC-10 to meet Air Force needs. As such, the Boom Operator and Cargo Loading trainers were developed to supplement the training provided by the commercially developed OFT. The Air Force is reviewing this approach for other Air Force missions to reduce training costs and minimize Air Force support personnel. Cost of the KC-10 OFT is $55 million.

KC-10 SCHEDULE MILESTONES

Contract Award: July 1980.
RFT: October 1982.
A/C IOC: March 1981.

GBU-15 Part Task Trainer (PTT)

The GBU-15 PTT is a stand alone part task trainer to provide training for Tactical Weapon Systems Officers (WSOs) in GBU-15 launch and guidance tasks. Training includes target acquisition/imaging and weapons employment from weapon release to target impact. The system will include a student station, a visual system to provide electro-optical and infrared imagery, a computation system and an instructor/operator station. The system will be generic to the GBU-15 weapon system and will be enhanced to provide training for F-15E, F-4E, and F-111F WSOs. Total cost is $38 million.

GBU-15 PTT SCHEDULE MILESTONES

Contract Award: May 1985.
Exercise Production Option: 1st Qtr FY 1987.
Ready for Training #1: 3rd Qtr FY 1987.
Ready for Training #6: 4th Qtr FY 1988.
GBU-15 In Production: January 1982.

T-46A Operational Flight Trainer

The T-46A OFT will provide ground based training for undergraduate pilot training (UPT). The T-46A OFT will be operational prior to aircraft IOC and will incorporate the existing T-37 OFT visual and motion systems. Total cost will be $129 million.

T-46A OFT SCHEDULE MILESTONES

Contract Award: September 1984.
Production Option: 1st Qtr FY 1987.
Ready for Training #1: 4th Qtr FY 1987.
Ready for Training #11: 4th Qtr FY 1992
Aircraft IOC: 2nd Qrt FY 1988.

C-5B Aircrew Training System

The C-5 Training System will be another example of a commercially provided training system. The computational and support systems of the C-5A OFT and CPTs are non supportable. Additional training devices are also required to meet the increased training requirements from the introduction of the C-5B aircraft. We have therefore structured a program to tie all elements of the C-5 training into a comprehensive program, and have requested and received proposals for a contractor produced and operated training system similar to the concept being employed on the KC-10. The system will provide complete ground based aircrew training for both the C-5A and C-5B. We expect to save time and money by allowing the contractor to use proven effective commercial practices and standards to produce the hardware and classroom instruction to deliver crewmembers trained to MAC performance standards. Total program cost will be $202 million.

C-5B ATS SCHEDULE MILESTONES

Contract: October 1985.
Partial System Operational: 1st Qtr FY 1986.
Full System Operational: 4th Qtr FY 1987.
Aircraft IOC: 1st Qtr FY 1986.

B-52 Weapon System Trainer

The B-52 Weapon System Trainer (WST) provides a full mission simulation capability with integrated training for the entire SAC Emergency War Order (EWO) Mission, in the same manner as is provided by the B-1 simulator discussed above. A total of ten B-52 WSTs have been procured. This includes six "G" models, four "H" models, one Offensive Station Mission Trainer (OSMT), and a Software Support Center. The total program cost is $420 million.

B-52 WST SCHEDULE MILESTONES

Contract Award: May 1980.
RFT No. 1: July 1983.
RFT No. 10: 3rd Qtr FY 1985.
OAS Blk II Update: 2nd Qtr FY 1987.
Aircraft IOC: In Service.

KC-135 Operational Flight Trainer (OFT)

The Air Force is planning to modernize its 1950's vintage MB-26/KC-135 cockpit procedures trainers which are unsupportable. This involves replacing analog computation systems with modern digital computers, updating performance characteristics for the new KC-135 reengining program, and providing a limited visual system. This involves development and modification of 19 units. Total cost is $150 million.

KC-135 SCHEDULE MILESTONES

Contract Award: 3rd Qtr FY 1985.
First Production Option: 3rd Qtr FY 1986.
RFT No. 1: 2nd Qtr FY 1988.
RFT No. 19: 3rd Qtr FY 1990.
Aircraft IOC: In Service.

To conclude our program review, I am happy to report the successful program management responsibility transfer of the C-130 Operational Flight Trainers, the A-10 Operational Flight Trainers, and the B-52 Weapon System Trainers. Management of these systems have been transferred from AFSC to AFLC.

Mr. Chairman, the last portion of our presentation addresses simulators now in service and our future plans. As part of our revised Air Force policy, we have initiated a program to speed-up critical modifications to existing simulators. This requires a two-phased approach, much as is done for aircraft in periodic depot maintenance. Safety-of-flight simulator mods will be made in-line with aircraft changes while other simulator mods will be accumulated and installed as block updates.

Each mod within the block update will be thoroughly evaluated by the MAJCOM and Air Force Logistics Command (AFLC) to make certain the flight simulator is the proper place to train the new capability. If so, the flight simulator interface will be developed concurrent with the modification. The maximum interval between block updates will be three years. Shorter cycles may be established by using MAJCOMs and AFLC to coincide with major aircraft modifications, such as for electronic combat. This approach puts priority on safety-of-flight changes while providing a disciplined approach for all other simulator mods.

As in the case of the C-5A and KC-135 Simulators, the F-4 simulators have been in the field for a number of years, but have reached the point where major modifications are required to keep the trainers useful. We have therefore initiated a refurbishment program.

In conclusion, we strongly urge your continued support of our vital Air Force training programs. If you have questions, I will be happy to answer them at this time.

Senator GOLDWATER. Thank you very much, General. And are you finished, General Chavarrie?

General CHAVARRIE. Yes, sir.

Senator GOLDWATER. Well, that was a very, very interesting presentation, and I want to congratulate you. It naturally raises some questions, and I will try to get through my questions rapidly, but as completely as I can.

I think I will start by asking General Chavarrie. It has been quite obvious, but if you have any comments, what procedures exist to bring the services together to share their views on simulator developments that consider the possibilities for joint efforts?

General CHAVARRIE. Yes, sir. I think their comments at the end of their briefings stated their interest in it, what we intend to do. You have got an OSD steering committee that is called a training steering committee, but under it is the subcommittee on simulators, and that has been in effect, been in being about, I would say, a year or a year and three-quarters.

So that will be the focus that will be the advocacy group for, No. 1, fighting our respective comptrollers when they try to take money away from this program, and No. 2, to get together so that we can capitalize on the joint efforts that we are doing together. So we have got an institution now to do it, and we hope it will work.

Senator GOLDWATER. Now, do you work with the manufacturer in this committee so that you will not duplicate efforts even down to the point of circuitry?

General CHAVARRIE. We will, yes, sir. To the extent that we have done it before, I am not sure, but we will.

Senator GOLDWATER. I think that is very important, because with today's advancements in electronics, as one who has lived his life in business, there is duplication going on every time you turn around.

General CHAVARRIE. We will look at that.

Senator GOLDWATER. Another question for each witness. How are your simulators funded, both the research, development, and procurement in each of the services? We will start with the Army, and the question gets down to, are they funded separately as simulators or as part of a major weapons system?

And let us start with you, General.

General KENYON. Yes, sir. In the Army, if we have a simulator that is related to a single weapons system, the funding for that simulator is the responsibility of the program manager. It is report-

ed in his program line descriptive summary, and appears to you all here in the Congress with his weapons system line. Funds are requested, however, under a separate budget line entitled, "Synthetic Flight Training Systems."

When we have simulators that are what we call nonsystem specific, then they appear in a composite line, and are provided to you with the detail, in a composite line without submission. For instance, our MILES system, the low level laser, which has application to the soldier, his individual weapons, the fighting vehicles, and so forth is requested in the nonsystem training device budget line.

The efforts we have ongoing to upgrade ranges and the training capability of those ranges is in this type of thing. But, for all of those that are related to a system to include aviation, armored vehicles, air defense and missiles, they are identified with the weapons system.

Senator GOLDWATER. Do you like that, or would you rather have it differently?

General KENYON. I like it that way, sir, because then, as you examine the funding and posture of a weapons system, you know during that review where you stand with your simulators and make sure that you fund them in synchronization with the weapons system, and you have the simulators for the various locations and capabilities as with the weapons system.

We found sometimes, for instance, if we speeded up a weapons system and earlier did not have the simulator considered at the same time, we did not speed up the simulator, so as we got them together, we think our program makes more sense, and we can keep it compatible.

Senator GOLDWATER. Well, let us for example say that you are working with Bell on a new product. Does the manufacturer find it difficult to keep up with Bell, or do they get the cooperation of Bell in developing a simulator to go along?

General KENYON. Yes, sir, that occurs at times. It depends upon the time linkage that you put with the weapons system itself and the simulator that goes with it. We have previously permitted the simulator to lag the weapons system a bit to accommodate to the freezing of the design and the changes made in the very early stages of production.

In the AH-64 Apache program, we have tried to link two prime contractors with Army linkage, though, to work together on a simultor to be fielded with the weapons system. It has caused some problems. However, I think in all cases I know of we have solved those problems.

Senator GOLDWATER. I will ask that of the manufacturers tomorrow. Now, let us move on to the Navy with the same question.

Admiral DUNLEAVY. Basically, the same answer, Mr. Chairman. The simulator is included in the weapons system, line 16. When we come over, the simulation is included in the total weapons system.

Now, again, like the Army, if we had something unique in the training ranges, that would come over as a separate item, but I personally, as a requirements fellow, I like to have one person responsible for that, the program manager. If I do not like the requirement, if he is not answering the mail, I go to one person in-

stead of trying to find someone else over in NAVAIR who I have to get after. So the program manager is the key man.

Do I like the prime being responsible for the simulator? Yes, sir. That is my personal opinion. Again, because I can go to one individual to get what I, the user, want, and you are going to get a lot of interesting answers from industry tomorrow on that one.

Senator GOLDWATER. You have gotten into one of my pet subjects now, program managers, and the big fault I find is, you guys hang around 2 or 3 years, and then you get out, and somebody else comes in that does not know anything about it, and they have to start all over again. Some day we may create a whole new series of program managers, but not now. I want to wait until I am just about to go home. [General laughter.]

Let us ask the same question of the Air Force.

General WILLIAMS. Senator, we, I guess, are very sensitive to that, and the way we approach it, we treat it as integral to the weapons system, and by that I mean the weapons system program manager is responsible for informing us and for tracking the development of the simulator as it comes along with the weapons system.

In a prototype, it is funded in the R&D program elements as a prototype, and as a cost of research and development. When he goes to procurement, then it goes into the procurement lines, albeit at the time being overviewed by the program manager.

Now, that is the weapons system specific one. Now, in addition to that we have a consolidated simulator SPO in the Air Force at Wright-Patterson, and within that SPO, that system office, they are responsible for all simulation programs in the Air Force, major simulation programs in most aircraft, except in this case for the C–5, because we are going with the contractor for that, and the E–3, which has some unique requirements, but other that those two programs, the system program office in the Air Force for simulators has overall integrating management for simulators.

So, we approach it in a sense in two ways, in kind of a matrix approach, where the program manager is responsible to answer and to be able to track and answer questions on his particular program, but at the same time we have a consolidated integrated approach through a special systems program office.

Senator GOLDWATER. Let me ask you a question. Is the 141 contracted now?

General WILLIAMS. Yes, sir.

Senator GOLDWATER. And to bring us up to date, would you say that the B–1 simulator is now ready to train potential pilots?

General WILLIAMS. No, sir.

Senator GOLDWATER. It is not?

General WILLIAMS. No, sir, not yet, and that has been a real concern to us, and as I mentioned during the briefing, we are going to the cockpit procedures trainer to ensure that we can cover those items of flight safety and that sort of thing that are most crucial to us prior to the arrival of the first aircraft in our initial operating capability.

We feel that takes care of those things that we are most concerned about in terms of safety of flight. It does not cover the full range of potential, though, that is possible in simulation for the

B–1 which is represented when the weapons system trainer, comes fully on line.

Senator GOLDWATER. But you think that by the time you get ready to check B–1 pilots out, they will have the simulator?

General WILLIAMS. Yes, sir. We would not do it any other way, sir. We could not afford that.

Senator GOLDWATER. Well, you have done it.

General WILLIAMS. Well, I am here to tell you, sir, that we do not plan to do that again.

Senator GOLDWATER. All right. Another question for each one of you. Are the force's fleet simulators seen as individual training devices, or do you consider simulators as part of an overall training system? And we will start with the Army.

General KENYON. Although most of our simulators today, Mr. Chairman, of course, are applied to or utilized by individuals at this point, although we want to get to larger units, the training that they get and the benefits are part of an overall training program. I will take aviation for a moment, where for each of the aviators in his annual training program, hours are specified, and a portion of those are specified to be in simulators.

As we field the conduct of fire trainers for our armor systems, that will become a part of the armor unit's annual training program, and I guess the broadest example, a place you have probably been, is our new national training center out on the west coast, where we move in by battalion sized units, our FORSCOM units of all types, against a permanent aggressor course there.

We use the entire MILES system as the capstone of a training program that a unit does in home station and in some training areas. So every instance I can think of, though they are utilized primarily by individuals, they are integrated into the overall training program.

Senator GOLDWATER. Navy?

Admiral DUNLEAVY. Sir, we have learned over the years, by hard experience, it has to be part of the weapons system. The simulator has to be an integral part of the overall system or it all falls apart and gets out of date. I guess the classic example is of the F/A–18 out at Lemoore, where the simulator is part of the program. It is a building block from the PTT to the CFT to the WTT up to the airplane.

And we fund it, we operate it, as an entity now. In the T–45 training program going to the Training Command down in Pensacola, and throughout our aviation training command, the simulators will be an integral part of the overall weapons system.

General WILLIAMS. Senator, one of the reasons we had two people come over here, we wanted you to know there was more than one Air Force general willing to talk about this subject, as well as the fact that in anticipation of some concern in this arena that I think motivated your question, that General Davidson, who represents the operational side of it, is sure that as I represent the research and acquisition side, that I do not give him a piece of hardware that is not totally integrated into what he really needs.

So, we feel that we are very sensitive to that, and we think we are doing the best job we can, but we will look and listen also for better ways to improve that as an overall integrated training

system. That includes ground training. That includes flight training, actual flight training. And that includes a full range of opportunities in simulation.

Senator GOLDWATER. Well, let me ask each one of you this, because I think you all as pilots know this. Fighter pilots have more or less historically avoided simulators like the plague since simulators were perceived as a threat to actual flying time and in general flew like simulators and not aircraft.

The question is, have you seen a change in attitude or greater acceptance by the fighter pilot of simulators? And how about the Army?

General KENYON. In our case, sir, we have gotten only limited exposure at this time in that the one simulator we have fielded in any large quantity is the UH–1, which is not really a weapons platform, but used in a utility role. However, I guess I was one of those guys you referred to that back when I was doing a considerable amount of flying, I much preferred to fly in an aircraft system versus that simulator, and it appeared in those days that a person could do that, in that there was some flexibility, and there always appeared to be flying hours available.

I have performed duty in our DCSOPS office, and I have been the deputy commandant at Fort Rucker in our training base, and I have seen a turnaround in those utility helicopter pilots already today, because the flying hours have not been available. They understand the need for training, and that simulator, as they got used to it, they now understand the benefits that they can get from it.

As we are expanding the simulator programs, we are trying to expand the flying hour programs, too, so that we have the best marriage and the best match for unit readiness.

I would forecast that as we get more into the Cobra simulator and fully into the Apache simulator, that those aviators will take to that, and will see the benefits of it, especially with the lack of capability to fire a large number of the armaments related to those systems. And we are going to promote that in the training base from the start, the way the other services have talked this morning, too.

Senator GOLDWATER. How valuable is the simulator to the new pilot in the curve of the earth procedures?

General KENYON. In nap-of-the-earth it is very important, sir, in that as you know now, that is one of the linchpins of our tactical operations with aviation. In the earlier types of simulations which General Williams showed in the 1970's you saw the revolution in that the aviator really could not get the feel, But in current computer-generated imagery that we are seeing today, and we will field in the Apache, we can do this training down in the nap-of-the-earth with those aviators on those simulators.

Senator GOLDWATER. Thank you.

Admiral DUNLEAVY. Yes, sir. A very positive turnaround in acceptance of the trainer and the simulator by the young fellows and the older fellows, because of what the industry has given us in the way of simulation and a feel for the aircraft. Again, it is supplemental, and not substitution for actual in-flight hands-on training.

You still get sweaty palms. You can work up a hell of a sweat, but you know you are still going to land the aircraft in a nice,

benign environment in a simulator. But the young guy, because of the really good simulation we are getting, and real visuals, and the reliability. We are up now to 95 percent reliable in our simulators versus years ago, when you would be lucky to have 50 percent availability.

We are getting better reliability from industry, better product, more realistic simulation, and the young fellows are accepting it.

General WILLIAMS. Senator, from the Air Force side, I guess I could begin by saying you do not fool the troops. If they have got something that helps them, something they believe in, and something that is sufficiently realistic, then they will use it, and that is what has been happening.

As Admiral Dunleavy just said, we are getting much better simulators now. Simulators have come a long way. Consequently, the young pilot who is willing to go over and look with an open mind at things now, he sees what he gets from that. The realism of training in the simulator has increased, but also the scope of the training.

And I guess we really need to be sure that is emphasized. The scope of the training possible in simulators now is far beyond what it used to be, and in some cases far beyond, as I tried to explain, far beyond what they can get in the aircraft, in the environment of the ranges, and in the environment of some of the avionic and electronic countermeasures.

We have to convince people of this, but I think that is why it is somewhat self-explanatory in that—well, you cannot see it as well as I had hoped.

Senator GOLDWATER. What is the left vertical?

General WILLIAMS. That is cumulative aircraft destroyed, rate per 100,000 of flying hours. In other words, as you go up, the rate is worse, so you want it to come down, and for the F-84, the F-100, and the F-86 earlier fighters you see without simulators there, without simulators that we have today, the rate is up.

Now, it is not all due to simulators. I am sure you appreciate that. But yet if you notice the solid filled in triangles there on the left for the F-16, the F-111, and the F-15, it is hard to prove precisely that they had an impact, but certainly we feel intuitively, and we think there is convincing evidence here that they played at least a large part.

Now, the crewmembers see this. They feel this. So there is a changing attitude, to answer your question directly, there is a changing attitude, and greater acceptance, because it works.

Senator GOLDWATER. Well, this is a good slide, and it is good proof. The big value of simulators today is not the actual stick. It is what are all of those buttons out there for, and the knobs and dials, and if you forget one of them, you are dead.

I will get to a question on that soon. I have just a few more. I was very interested in the Army's explanation of tank simulation and other weapons simulation, because sometimes we tend to think of simulators as related to aircraft only.

I am familiar with the M-1 tank, and while an old guy like me can take that cannon and hit a target, I imagine anybody can. All the gadgets around it, it takes quite a bit of training, and you have

done the simulation work on that, and I suppose with all of your advanced weapons systems you more or less can simulate the procedures.

General KENYON. And that is the first thing we look to do, sir, in the most comprehensive of the systems that you saw, the M–1 Abrams. But as all of our systems come on line, we do both operator and maintenance training procedures. We are looking at the Sergeant York, DIVAD, and the Patriot.

All of the missile systems have training devices, and some of those you have seen, the Stinger, the Redeye, the TOW. And so that we apply it as widely across the board as we can.

Probably one area that I covered that we are giving even increased importance to, though, is the individual soldier, and that is that MILES system, the integrated laser system, where when he detects a target, he can shoot at it and know whether or not he hits it, and know whether or not he is being hit also.

Senator GOLDWATER. General Chavarrie, how is the HRL system working out?

General CHAVARRIE. I think probably the Air Force could answer that better, Senator, but I think it is working. I think it is working very well. And I think the important thing is that I think they look to the future more than probably other organizations do, and well they should, but I would say particularly looking to the future they do really excellent work.

Senator GOLDWATER. I am very impressed with it. I think it is certainly a step forward. Are you integrating this facility with the other services?

General CHAVARRIE. We have just begun to talk about that. As a matter of fact, the last meeting we had among ourselves we talked about how we can integrate this kind of thing like HRL into what the other services are doing, and so I would say as far as that is concerned we are beginning it.

Senator GOLDWATER. Well, I hope you proceed, because it is always a temptation for each service to have the similar service, and we are trying to get away from that.

Back to the Army, in your discussion of the simulators for the AH–64, you did not mention the gunner, and the simulation of at night or dusk or smoke-obscured siting. Have you provided that?

General KENYON. Yes, sir, we have. The AH–64 combat mission simulator will have a station for each crewmember, the pilot, and the gunner, and in, say, the gunner's cockpit all of the sensors that are available to him in that aircraft system are in that simulator. Likewise for the pilot, so that he has the direct view optics, the pilot has the helmet integrated site which you have flown before.

The gunner also has the FLIR and the day TV, and we are, though it is not totally developed, we will provide the changing scenes within the computer-generated imagery just the same as we have in the tank and armored fighting vehicles.

Senator GOLDWATER. I think that is very important, and I think that is one of the best parts of that helicopter.

Now, I think it was the Air Force in your last display of slides showed some black box over the eyes?

General WILLIAMS. Yes, sir.

Senator GOLDWATER. And that is to show you everything that is ground?

General WILLIAMS. Yes, sir.

Senator GOLDWATER. What are you going to do about the fighter pilot who turns his head?

General WILLIAMS. I hesitate a little bit on that one, Senator. And we are looking at it. I guess I would like to say we are not unwilling to look at anything, but we do have some concern as to the full utility of that. I suppose we have some confidence that even if it does not work for the fighter pilot, maybe it will work for some others.

We have got some work to do there. I do not have a better answer.

Senator GOLDWATER. You quit teaching that guy to move his head around and he is going to get killed.

General WILLIAMS. That is right, sir.

Senator GOLDWATER. Now, the Navy, do you have simulators for rocket firing?

Admiral DUNLEAVY. Yes, sir. The F/A-18 dome has rockets and missiles in it.

Senator GOLDWATER. I mean shipboard firing. Say the SLCM.

Admiral DUNLEAVY. I will have to go home and get that answer for you, Senator. We do have simulators down on the piers we can crank into our ships command and control system. Whether or not we have an actual missile firing from the ship, I will have to come back and give you the answer for the record.

Senator GOLDWATER. I would be interested in the simulation that is available in the Navy for shipboard firing, and I would imagine that would include submarine. So if you have available printed material on that, we would like to have it for the record.

Admiral DUNLEAVY. Yes, sir, we will do that.

Senator GOLDWATER. I am told that we told you to concentrate on aviation and warfare simulators. I guess we do not have warfare off ships any more. [General laughter.]

Now, this is a general question, and it does not necessarily apply to simulation. I think the big complaint of pilots all down through aviation history has been the confused, cockpit, the fact that it has taken us since the days of the Wright brothers to come up with a cockpit, one that is big enough to get into without crawling over everything, and two, that has a simple instrument panel.

I was allowed to see the cockpit of the new Boeing 757 the other day, and the C-17 mockup has it where everything is cathode ray displayed. My interest as a pilot is, are we tending toward standardized cockpits, not necessarily a C-5 cockpit, that can be put in the F-16 with a six-place cockpit.

But are we standardizing the cockpits in the big birds and the small birds so that when you get in the cockpit, if you do not see a red light, you go? You do not have to read a lot of dials? Are we getting there?

General CHAVARRIE. Sir, I think probably the Air Force and the Navy could answer that better. Let me just say from my experience I think we have come from relatively simple stuff years ago, when I went through, to very complicated technology, because technology became complicated, and everything that was complex was good,

and everything that was simple was not good, because what was simple was old.

I think we are probably turning the corner a little bit. I am certainly not a scientist, but it seems to me that we are finally realizing that complexity is not good for its own sake, much like a lot of people say you centralize something because it is good, that it just per se is a good thing, and we know that is not true.

So, I think getting more complex is not good, and I think it is a syndrome we have had, and it is just part of our society, but I believe that we are now getting smart enough to see the noncomplexity of things and how simple they can become.

That could, I think, be integrated into something like a cockpit, which is a complicated affair, I think it is within reach. I perceive that your are saying that that kind of thing should come, making it simpler, and I think all we have to do is say, do it, and mean that we want to do it, and I am sure that industry could do it just as slick as they could do anything else.

So, I think we have become simply too complicated and are headed in the direction the way I perceive you are saying, Senator.

Admiral DUNLEAVY. What we are hearing from industry is that we are at the knee of the curve. To go to a completely cathode ray tube instrument panel is almost more economical than going back to the old dials and wheels, and the young people today react to a cathode ray tube cockpit a heck of a lot more positively than looking at all of the dials and bar graphs and things of that nature.

A computer-generated display the kids respond to, they react on it. And it is beautiful to watch. Maybe it is a spinoff of our young guys spending time with video games instead of the pinball machines when you and I were kids.

But they react to that, and they are coming along, and according to industry, we are almost at the knee of the curve in the economies for that kind of a cockpit, so we are seeing a positive influence in that.

General WILLIAMS. Senator, you have touched a nerve in that the technology can now far outstrip the function required. In fact, as you were saying, I think, and we certainly agree that it can become more of a negative than a positive. What needs to be done is more effective management of all of that capability to provide the pilot what he really needs.

I guess we are doing several things. One, we have a cockpit automated technology project under the Aeromedical Research Lab, which is another human factors look, as well as the Human Resources Lab, which you are going to be briefed on tomorrow by Colonel Eliason.

The Avionics Lab and industry are all cooperating, and to give you a specific example, in the F–16 we thought that with the multimode display, that you could put anything you want on it. We learned that that was not necessarily as functional an answer as we initially had thought.

Such things as changing the radio, we would plug in the numbers, and you may have done this yourself, plugged in the numbers, and then it took only a little bit of time, but that little bit of time was very, very unfortunate for the pilot. He likes to dial his num-

bers and then forget about it. And his frequency comes up, and he is working.

In this case, dialing it, that captured this multimode display for only a few seconds, but those few seconds were precious, and we have gone back in, and fortunately, we can accommodate those requirements now.

We learned that by getting the crew members involved at the right time, and we have what is called a front end analysis effort that is going on now to get the real crew members, the guys who are going to put their hands on it, involved with the engineers and the human factors people early on to try to adjust more realistically to the capability of technology, to provide us today with what the pilot and crew members really need.

So, sir, you have touched a very important point, and we were a little late in learning that. I guess if we had been over here a little sooner, maybe we could have gotten this sooner.

Senator GOLDWATER. Well, that gets me into my next question, but I might say that we are very close to the time when the pilot can ask for the frequency 118.5, and there it is. If we can get the Navy and the Air Force to work together on that, I think we could get it.

Now, this leads me to another question with the new pilots. The younger pilots who are being brought up in the heads up display. I do not imagine you are running into much trouble, but let us take the pilot who is old enough not to have been around.

Are simulators helping you train that type of pilot? Or are they finding difficulty even with the simulator in acquainting themselves with the peculiarities of HUD flight?

Admiral DUNLEAVY. It is like training old dogs to do new tricks. We keep hammering on them all the time, and again, when a guy straps on an airplane, he goes out and he does what he wants to do.

You can train him in the simulator, and beat it into his head that he shall do it this way, but what he does when he is on the glide slope, whether using the HUD or looking outside, that again is up to him. What does he do? We have seen no indication that the older fellow—and when you are talking about an older fellow, you are talking about a 38-year-old man nowadays—and he has learned to use the HUD. He is flying in different aircraft, and he is doing it quite well.

So, I cannot really tell you, yes, we are having a hard time with it. I have seen no indications that the older fellows, the 38-, 40-year-old pilots are not accepting the new HUD. It is a great mode simplifier, and the better graphics we are getting up on it, the more acceptable it is to the older fellow.

The younger guys are all on board.

General WILLIAMS. I think Admiral Dunleavy said it right, that the simpler we have it, the better. There was something that we learned that once again we should have realized, I guess, earlier, and that is that your HUD symbology for flight direction, flight vectors, whatever, needs to be sufficiently similar to your normal flight symbology so that when you go from your head up display down to your normal cockpit display, you do not have to do too much of a transition, particularly for younger pilots who do not

have the background of such familiarity with the cockpit displays that then they just relearn the HUD.

It is very important that the two types of symbologies are sufficiently similar. I did not say identical, but sufficiently similar so that there is not a transition problem from the cockpit instrument to the head up display.

In terms of simulators, the head up display with a visual display in front of it gives a sufficiently realistic view but without the visual. Then you have a little accommodation to do, whereas in other words in the actual airplane you see the head up display with no picture or with a picture behind it.

If in the simulator you do not have that picture, then there is a disparity there.

Senator GOLDWATER. Let me ask you, is the Air Force requiring HUD display at Red Flag? Or is it optional?

General WILLIAMS. I guess I am not sure. The full extent—if the aircraft weapons system has a head up display in it that is required for it to do its mission, then it would be required for a Red Flag operation, Senator, if I understand your question.

[Additional information follows:]

HUD DISPLAY AT RED FLAG

In the context of a Red Flag training mission, the heads up display (HUD) is required for effective use of aircraft weapons systems. The use of the HUD in this context is often mandatory. It provides the pilot a significant advantage over aircraft not similarly equipped. Although backup employment modes are provided, the use of the HUD is universally preferred.

Senator GOLDWATER. That is the question. And is the Navy the same way?

Admiral DUNLEAVY. Yes, sir; if it is part of the aircraft, we expect the guy to use it, but then again, whether or not he is going to use it is up to the way he is trained. We train them to use it, but again, it is his final decision whether or not he is going to utilize that great asset. But with God's help they all use it, and when Navy squadrons go to Red Flag, they go with full up rounds, and that includes the HUD.

Senator GOLDWATER. And the Army is using HUD, I believe, on the AH-64.

General KENYON. On the AH-64, yes, sir, for the first time, and we found a little problem in acclimation. However, we have kind of loaded the dice in that we are being selective. The aviators that are going into the AH-64 initially are those who have AH-1 Cobra experience.

Senator GOLDWATER. Well, I have just about run out of things, but I would like you each to provide the staff with the total authorization requested in 1985 for each of these areas, flight simulators, other related training devices that require authorization, a modification for these devices, and research and development by program element and project.

And then I would like you to, if you can, provide the same data for the five year defense plan.

I think all of my other questions have been answered, but I just want you to go away knowing that at least for the next 2 years you have a guy that is very interested in simulation. I recall very

vividly when I was required in my squadron to provide pilots to fly 100 hours a year or a month in the old Link trainer, and the pilots never showed up, so I had to do the flying. [General laughter.]

[Questions with answers supplied follow:]

JOINT EFFORTS

AIR FORCE

Senator GOLDWATER. What procedures exist to bring the services together to share their views on simulator developments and to consider the possibilities for joint efforts?

General CHAVARRIE. There are five mechanisms in place to bring the services together to share their views on simulator developments and to consider the possibilities for joint efforts. First is the OSD Steering Committee on Training and Training Technology. This committee, made up of the Deputies from key OSD offices, meets at least semiannually to review and sets policy for all major training activities in the DoD. As the current chairman of the committee, I have placed special emphasis on fostering joint efforts. Secondly, senior managers of all services participate on a Training Activities Subcommittee of the Steering Committee, and make funding recommendations and decisions for engineering development of proposed training devices and training technology-related projects. *One of the ground rules for their funding decisions is that the devices must be of use to at least two Services.* Third, we have recently chartered the Defense Training Data and Analysis Center to be the focal point for training requirements, procedures, and information/data with multi-service applications. Fourth, we have staffed through the services and provided to Congress a uniform set of guidelines for simulator development and acquisition. The guidelines will stimulate the sharing of views, and will require certain specific kinds of data to be provided to the Training Data and Analysis Center for joint service use. Finally, there is a committee established by the Joint Logistics Commanders to review service initiatives in simulation and training devices. This committee serves as the primary user coordination activity at a high enough level to be effective.

These five coordinated efforts provide the OSD with a comprehensive review capability to preclude unnecessary duplication.

SIMULATOR FUNDING

Senator GOLDWATER. How are simulators funded (both R&D and Procurement) in the (Army, Navy, Air Force)? (What are the reasons for any differences in funding approaches?)

General WILLIAMS. In the fiscal year 1985 budget request, the Air Force consolidated funding of flight simulator development within the Flight Simulator Development program element. Procurement is funded two ways: within the aircraft procurement line for in-production aircraft and within the common support equipment line for out-of-production aircraft.

SIMULATORS AS INDIVIDUAL TRAINING DEVICES

Senator GOLDWATER. Does the (Army, Navy, Air Force) treat simulators as individual training or do you consider simulators as part of an overall training system?

General WILLIAMS. The Air Force considers simulators as an element of the training system. In Air Force Regulation 50–11, Management of Training Systems, a training system system is defined, "The training equipment" (items used for depicting, simulating or portraying the characteristics of a piece of equipment, system or facility)" and related support of a major weapon system. . . ." "The training system will be planned and managed as an integral part of the weapon system."

The Air Force requires each training system to be developed in accordance with Air Force Regulation 50–8, Instructional Systems Development (ISD). The ISD process requires a thorough front end analysis of the weapon system to determine the specific training requirements for meeting the mission objectives. These training requirements are then arranged in a progressive learning pattern and the proper

media for each learning objective is selected. The simulator is an integrating element in the training system, bringing the lower level objectives together in a high fidelity training environment. The Air Force requires that the integration of the training system be spelled out in the Training Development Plan (TDP). The TDP is produced concurrently with the conceptual stages of a new weapon system and updated as necessary during the development of the system.

CENTRALIZE MANAGEMENT OF SIMULATORS

Senator GOLDWATER. What is being done in the (Army, Navy, Air Force) to centralize management and accountability over the development and procurement of simulators?

General WILLIAMS. Management and accountability for Air Force flight simulators is centralized in the Simulator System Program Office (SPO) within the Air Force System Command. Maintenance trainers are managed through individual system program offices. This centralization within the Air Force enables us to better share simulator development and procurement with the Army and Navy. Further, in fiscal year 1981, a dedicated position was established at the Air Staff to oversee the development and acquisition of all flight simulator programs. This structure parallels that which exists within the MAJCOMS, all of whom have offices dedicated to the management of their training programs. To further centralize management and accountability, we are investigating expansion of the Simulator SPO to a Training Systems Program Office.

BREAKOUT OF SIMULATORS

Senator GOLDWATER. How many different flight simulators are currently in production or development for the Air Force? Please provide a breakout of these simulators.

General WILLIAMS. The following simulators are either in development or production in fiscal year 1985:

B-1B Simulator: Weapon System Trainer (SWT); Cockpit Procedure Trainer (OFT).

T-46 Operational Flight Trainer (OFT)

F-15C/D OFT

F-15E WST: Part Task Trainer (PTT); Cockpit Familiarization Trainer (CFT); Emergency Procedures Trainer (EPT); Computer Based Instruction (CBI).

F-16 OFT: Digital Radar Landmass System; Electronic Warfare Training Device; LANTIRN Subsystem; PTTs.

HH-60A: WST; CPT; PTT.

KC-135 OFT.

LANTIRN Core Simulation.

LANTIRN PTT.

GBU-15 PTT.

B-52 Offensive Avionics Station.

C-5/C-141 ARPTT.

C-5 Aircrew Training System.

EF-111A OFT.

KC-10A.

FISCAL YEAR 1985 AUTHORIZATION REQUEST

Senator GOLDWATER. Provide the total authorization requested in fiscal year 1985 for each of the following:

Flight simulators; Other related training devices (requiring authorization); Modification for these devices; R&D by Element and project.

Provide the same data for the Five Year Defense Plan.

General WILLIAMS. The total authorization requested in fiscal year 1985 and The Five Year Defense Plan follows: ($ million):

[In millions of dollars]

	Fiscal year—				
	1985	1986	1987	1988	1989
a. Flight simulators:					
Research and development weapon system line	140.7	131.7	61.4	24.4	41.9
Procurement	492.9	340.0	275.4	226.4	178.5
b. Other related training devices (maintenance training equipment)	107.5	98.5	50.1	57.1	35.3
c. Modification for these devices[1]	23.0	50.4	106.7	71.5	24.8
d. R&D by program element and project:					
(1) PE 64227F, flight simulator development project:					
2851 standard DMA data base transformation program	1.430	1.500	1.401	1.642	.....
2325 simulator development activities	4.120	8.407	7.190	6.579	7.030
2985 simulator R&M	2.344	.988	.025	.025	.....
2968 sim modularity design	1.333	3.294	3.269	4.000	.....
Total for PE 64227F	9.227	14.189	11.885	12.246	7.030
(2) PE 63751F, training systems technology project:					
2359 pilot performance measurement	.040	.....	.....	.....	.....
2362 computer based maintenance aids for technicians	.700	.475	.....	.....	.....
2557 advanced OJT system	1.860	1.900	2.000	1.800	.....
2744 unified data base application	1.500	1.500	2.000	.....	.....
2745 logistics for combat readiness maintenance	.970	1.006	1.479	2.556	3.387
3056 air combat assess debrief system	.....	.....	.....	1.450	2.680
3057 portable intell CAI	.....	.....	.....	.300	.600
Total for PE 63751F	5.070	4.881	5.479	6.106	6.667
(3) PE 63227F, advanced simulator technology project:					
2363 advanced visual technology systems	5.960	3.130	3.100	3.300	3.900
2743 advanced simulator concepts	1.526	1.377	1.367	1.362	1.289
Total for PE 63227F	7.486	4.507	4.467	4.662	5.189
(4) PE 62205F, training/simulation technology project:					
06HT laboratory support	6.738	6.675	6.794	6.910	7.028
1121 technical training development	1.630	2.400	3.130	2.200	2.500
1123 flying training development	2.800	3.300	3.350	2.601	2.865
1192 advance simulation for pilot training	5.400	6.058	5.993	5.600	6.078
1710 logistics and maintenance technology	4.300	5.100	6.034	5.000	5.100
3017 command and control training	.572	.672	.700	.700	.700
6114 flight simulation technology	1.800	2.900	3.696	2.280	2.800
Total for PE 62205F	23.240	27.105	29.697	25.291	27.071

[1] Note: Includes modification programmed for all flight simulators in the active inventory.

DELIVERY OF FIRST SIMULATOR

Senator GOLDWATER. Should the first simulator for a major weapon system be planned for delivery before or after the delivery date of the actual weapon system? What is the current practice? What benefits would you expect to realize from delivering the first simulator ahead of the weapon system?

General WILLIAMS. The Air Force considers having a safety-of-flight simulator prior to initial operational capability a critical training requirement. In fact, Air Force policy requires that a safety-of-flight simulator be available prior to delivery of a new weapon system. The warfighting simulator or weapon system trainer (WST) is expected to be delivered within a reasonable period of time following stabilization of weapon system design. The reason for this seeming disparity is that the complexity of building the WST often exceeds the complexity of the weapon system because of integration of software and modeling of aircraft capabilities. During initial acquisition the weapon system and its capabilities are constantly changing. This inhibits concurrent or early delivery of the WST. The less comples, safety-of-flight trainer called a Cockpit Procedures Trainer (CPT) can be developed and fielded prior to delivery of the weapon system. This is true, for example, in the case of the

B-1B. The CPT will be available in FY 4/85, approximately one year prior to Initial Operational Capability (IOC) of the B-1B. It will provide training in normal and emergency procedures as well as instrument training.

Benefits of early acquisition of the safety-of-flight simulator include better trained instructors and aircrew members in emergency, normal and instrument procedures prior to flying the aircraft.

F-15 FLIGHT SIMULATORS

Senator GOLDWATER. What is the status of the F-15 flight simulator program? Provide the delivery schedule and planned location for each simulator.

General WILLIAMS. The F-15 simulator is in production with a total of fourteen A and C model trainers required. Ten have been delivered; three are in various stages of production; the final trainer is scheduled for procurement in fiscal year 1986. Two major changes to the baseline are in process, the Multi-Staged Improvement Program (MSIP) and the F-15E changes due to incorporation of the Tactical Fighter Roadmap. Both are to maintain configuration compatibility with the aircraft. An additional six F-15E Weapon System Trainers are anticipated, making the total buy twenty (20) devices. Delivery schedule and locations are:

Unit	Delivery	Location
1	DEL	Luke AFB.
2	DEL	Holloman AFB.
3	DEL	Langley AFB.
4	DEL	Bitburg AB
5	DEL	Luke AFB.
6	DEL	Kadena AFB.
7	DEL	Eglin AFB.
8	DEL	Elmendorf AFB.
9	DEL	Tyndall AFB.
10	DEL	McChord AFB.
11	May 86	Tyndall AFB.
12	Nov 86	Minot AFB.
13	Aug 87	Griffiss AFB.
14	Dec 87	(AFRES/ANG) TBD [1]
E1	Apr 88	Luke AFB.
E2	FY 89	Do.
E3	FY 90	TBD [1]
E4	FY 90	Do.
E5	FY 91	Do.
E6	FY 93	Do.

[1] Beddown being finalized.

A-10/F-15/F-16 VISUAL SYSTEMS

Senator GOLDWATER. How many A-10/F-15/F-16 visual systems will be procured and on what schedule? What is the projected cost of each of these systems?

General WILLIAMS. The Air Force has no current plans to procure A-10/F-15/F-16 tactical visual systems. As a result of development problems on the Tactical Combat Trainer, cost constraints, and technology limitations, we are still evaluating visual system requirements, deployment concepts, and the potential contribution to training. Pending the results of Project 2363 and the emerging technologies, the Air Force will make a decision on fighter visual systems in the near future.

"INTERMEDIATE" VISUAL SYSTEM

Senator GOLDWATER. Does the Air Force plan to buy an "intermediate" visual system for the A-10/F-15/F-16? Describe this "intermediate" system, give its cost and show the acquisition schedule. Will the Air Force still procure a tactical visual system later on? If so, how many and on what schedule?

General WILLIAMS. The Air Force has no plans to procure an "intermediate" visual system for the A-10/F-15/F-16. As a result of development problems on the Tactical Combat Trainer, cost constraints, and technology limitations, the basic re-

quirement for the full visual system was amended in 1982 to provide for procurement of an intermediate system. However, because of the high cost and still emerging technology of fighter attack visual systems, we are still evaluating requirements, deployment concepts, and the potential contribution to training. A production intermediate visual system, consisting of a five window display and a computer image generator using conventional state-of-the-art technology, is expected to cost approximately $8 million. The Air Force has no definitive plans to procure the intermediate visual systems, but based on the emerging technologies and pending the results of Project 2363, the Air Force intends to reexamine this issue in the near future.

B-1 FLIGHT SIMULATORS

Senator GOLDWATER. What are the Air Force's plans for the B-1 flight simulators? Provide an acquisition schedule by fiscal year along with the funding requirements for the B-1 flight simulator program.

General WILLIAMS. The Air Force plans to buy five Weapon System Trainers (WSTs), one or two Mission Trainers (MTs), and up to six Cockpit Procedures Trainers (CPTs). The flight simulators will be located at four operating bases to provide training for all B-1B crew members. The acquisition schedule and funding requirements are as follows:

	Fiscal year—							Total
	1983	1984	1985	1986	1987	1988	1989	
WST BUY (QTY)			(3)	(2)				(5)
Delivery (QTY)						(2)	(3)	(5)
MT BUY (QTY)				(2)				(2)
Delivery (QTY)						(1)	(1)	(2)
CPT BUY (QTY)			(3)	(3)				(6)
Delivery (QTY)				(2)	(4)			(6)
Funding requirements (TY$M):								
R&D (3600)	3.4	9.6	51.8	40.1	21.4	.8		127.1
PROD (3010)			157.9	136.0	1.6	1.7	5.3	302.5

B-1 FLIGHT SIMULATORS IOC

Senator GOLDWATER. Provide a chart that shows how the IOC of the B-1 flight simulators will support the IOC of the B-1's.

General WILLIAMS. Aircraft vs Simulator Delivery Schedule:

Base	Aircraft delivery	Simulators* IOC (1st device)		
		CPTs	WST	MT
Dyess AFB TX	Sep 86 (IOC)	Jan 86	Oct 87	Aug 88
Ellsworth AFB SD	Jan 87-Sep 87		Apr 88	
Grand Forks AFB ND	Oct 87-Feb 88		Oct 88	
McConnell AFB KS	Feb 88-Jun 88		Jan 89	

*CPT—Cockpit Procedures Trainer, WST—Weapon System Trainer, MT—Mission Trainer.

The CPT will provide initial training to include safety-of-flight training of aircrew personnel and will be available nine months prior to the aircraft IOC. Initial crews entering training will be highly experienced, individually selected, and have prior B-52 or FB-111 experience. The WSTs will be available to support entry of less experienced aircrews into the B-1B program.

HEAD-TO-HEAD "FLY-OFF"

Senator GOLDWATER. What are the pros and cons of applying the head-to-head "fly-off" procurement strategy to simulators as was done in the B-52/KC-135 competition?

General WILLIAMS. PRO: The B-52/KC-135 Pilot Production Units (PPU) "fly-off," which took place at the conclusion of AF qualification testing of the PPU devices, provided the Air Force the ability to make a decision based on hardware, software, preliminary documentation and cost. A comparison of each vendors' equipment capabilities and production cost proposals provided a unique competitive environment to make a more informed production decision. Additionally, contractors were provided a performance specification, with wide latitude allowed in the simulator approach.

CONS: The cost to retrofit each prototype B-52 WST to a production configuration was roughly equivalent to the cost of procuring a new production device. As a result, subsystems of the B-52 WST are being used by the Air Force Human Resources Laboratory, the Aerospace Medical Research Laboratory, and the Aeronautical Systems Division to conduct research. However, each of the KC-135 simulators, which is less complex and is based on a more stable aircraft configuration, was retrofitted to the currrent configuration and is being used for KC-135 training.

Given our experience in using the "fly off" approach in simulator procurements, we structured the B-1B WST to carry competition through the Preliminary Design Review. This approach appears to incorporate the primary advantages in the "fly-off" approach in a complex program but without incurring the large expense of producing two separate devices.

BASING PLAN FOR THE B-52 WSTS

Senator GOLDWATER. What is the basing plan for B-52 WSTs

General WILLIAMS. Basing plan for B-52 WSTs:

WST# and base	Model	QTR/FY
1 Castle AFB CA*	H	2/84
2 Griffiss AFB NY	G	3/83
3 Wurtsmith AFB MI	G	1/84
4 Grand Forks AFB ND	G	1/84
5 Castle AFB CA	G	2/84
6 Minot AFB AFB	H	3/84
7 Carswell AFB TX	H	4/84
8 Blytheville AFB AR	G	4/85
9 Castle AFB CA	G	1/85

*Will move to Sawyer AFB MI following modification, 2/87.

B-52/KC-135 PROTOTYPES

Senator GOLDWATER. How have the B-52 and KC-135 prototypes that were not selected for production been utilized? What are the plans for these units? Since they are "one-of-a-kind" devices, what problems have been encountered in the support of these unique B-52/KC-135 WSTs?

General WILLIAMS. The B-52 Weapon System Trainer (WST) nonselected for production was provided to Air Force research activities as research components. These components are being used to conduct research in areas such as synthetic aperture radar, infrared, visual data base, simulations, as well as for training effectiveness studies.

The KC-135 WST nonselected for production was converted to a KC-135R operational flight trainer (OFT). This will allow Air Force pilots to train on a simulator which models the performance of a re-engined KC-135 concurrent with delivery of the aircraft and before the production KC-135R Operational Flight Trainers (OFT) become available in FY88.

Support for the prototype units is costly. Many of the components have limited spares so that unless the unit can be cost-effectively modified to a production unit, it becomes nonsupportable. This was overcome in the case of the KC-135 WST by con-

tracting with Boeing to convert the simulator to KC-135R status and contracting for Boeing support of the simulator.

KC-135 TRAINING

Senator GOLDWATER. What are the flight simulator plans, if any, to provide KC-135 training? How is KC-135 training being provided? Are any KC-135 flight simulators planned in the fiscal year 1984 budget?

General WILLIAMS. The Air Force is in source selection for refurbishment of existing KC-135 simulators. At present, the Air Force uses the KC-135 Weapon System Trainer (WST) prototype based at Castle AFB, CA, and 19 existing KC-135 simulators. These 19 simulators will be refurbished to KC-135R and KC-135A status beginning in fiscal year 1988 to fiscal year 1990, and the KC-135 WST which was nonselected following the WST competition will be modified to KC-135R status to provide training to aircrews concurrent with initial delivery of the aircraft. The nonselected KC-135 WST conversion to KC-135R is in the fiscal year 1984 budget, and refurbishment of 19 KC-135 simulators is planned in fiscal year 1985 to fiscal year 1990 (first delivery FY 1/88).

RC-135 TRAINING

Senator GOLDWATER. Are any RC-135 flight simulators planned? If so, in which fiscal year will they be funded? If none is planned, how is training being accomplished?

General WILLIAMS. One RC-135 simulator is planned. We are contracting with industry to modify a commercial 707 simulator to an RC-135 configuration. It is contracted on a lease-to-buy basis with full contractor maintenance. The simulator will be ready for training in FY 85 and will be located at Offutt AFB NE. Limited training is presently accomplished in the KC-135 simulator and the classroom, with most training being accomplished in the RC-135 aircraft.

C-5/C-141—COSTS FOR MAJOR SYSTEMS OF THE CPT

Senator GOLDWATER. Provide an estimated cost for each of the major systems of the CPT to show how the total cost was determined.

General WILLIAMS. Estimated costs for the major systems in the C-5/C-141 ARPTT ($TY) are:

[In millions of dollars]

	Research and development	Production*
Student station	$2.396	0.676
Computation system	1.492	.446
Visual system	7.277	5.074
Vibration/buffet system	0.149	.033

*Based on six devices.

The most recent cost estimate was the most probable cost to the government estimate completed in source selection in August 1983. The primary methods of estimating the cost were the RCA PRICE hardware and software models. The PRICE models used physical inputs provided by the competing contractors in their proposals. The PRICE models were cross checked by engineering buildups, historical factors, historical cost curves and supplemented with three operating and support cost models.

C-5/C-141 MILITARY SPECIFICATIONS OF THE CPT

Senator GOLDWATER. Will these systems be built to military specifications? If so, why is this necessary, and what is the estimate of the cost increase due to conformance with military specifications?

General WILLIAMS. The C-5/C-141 Air Refueling Part Task Trainers (ARPTTs) are not being built to military specifications even though some military specification aircraft parts are being used. Our dominant simulator acquisition strategy is competitive and we posed no penalty if a contractor proposed military specification parts in his design. Smaller competitors, those lacking a large manufacturing capa-

bility, tend to rely more on actual aircraft parts in their design. The selected C-5/C-141 ARPTT contractor won in August 1983 based on price and a design that included limited use (less than five percent) of military specification aircraft parts. Off-the-shelf hardware is built to commercial standards. Small parts, such as integrated circuits used in simulators, must be on an approved list that is made up largely of military specification parts. This is driven by the need to be able to use spare parts in the Air Force supply system without having to carry separate parts for simulators.

HH-60 FLIGHT SIMULATOR

Senator GOLDWATER. The committee understands that the Air Force will request funds for an HH-60 flight simulator in fiscal year 1984. Please provide a funding profile and acquisition schedule for this flight simulator.

General WILLIAMS. The Air Force is restructuring the HH-60 flight simulator program to provide simulator deliveries concurrent with delivery of the weapon system. The presently approved program is as follows:

[In then year dollars in millions]

	Fiscal year—						Total
	1985	1986	1987	1988	1989	1990	
R&D (3600)			0.5	14.3	30.8	26.2	71.8
PROD (3010)					4.1	48.1	52.2
WST BUY				(1)		(1)	(2)
Delivery							(2)

VISUAL SYSTEM FOR HH-60 FLIGHT SIMULATORS

Senator GOLDWATER. What type of visual system will the HH-60 flight simulator use?

General WILLIAMS. The HH-60 flight simulator is planned to use a Computer Image Generator (CIG) visual system for all four windows of the cockpit. This visual system will permit realistic training during simulated day, dusk, and Night Vision Goggle (NVG) compatible operations. It will provide high resolution scene detail for takeoff, landing, search and rescue, threat environments, and a variety of terrain types.

FUNDING OF HH-60 FLIGHT SIMULATOR

Senator GOLDWATER. Will the Air Force consider a joint procurement with Army for this flight simulator? Will the initial flight simulator be funded through R&D or Procurement?

General WILLIAMS. A joint program has been considered, but mission and cockpit differences between the HH-60A and the UH-60A helicopters cause major simulator design differences which would not result in cost savings for a common simulator program sole source to the UH-60A simulator manufacturer. The major design differences on the HH-60A include advanced avionics including multi-function displays, Forward Looking Infra-red Radar (FLIR) simulation, greater visual requirements, and a three-position cockpit (versus tow in the UH-60A). These differences significantly affect software development and architecture which are major cost drivers. While there is a large degree of commonality between airframes, this is not a significant cost driver in simulation. However, the request-for-proposal will be structured such that contractors will be given the latitude to propose applicable existing designs to meet the training requirements. The competitive process will therefore incorporate commonality into the evaluation. The one Weapon System Trainer, one Cockpit Procedures Trainer, and the first Part Task Trainer will be funded through R&D.

TRAINING PROGRAM FOR THE KC-10

Senator GOLDWATER. The Air Force has recently contracted for a "best commercial practices" training program for the KC-10. Describe the program from a con-

tractual standpoint with details on such things as specifications, warranties, performance objectives, etc.

General WILLIAMS. Growing from the advanced tanker/transport initiative, the KC–10 program was, from its inception, oriented toward commercial practices and specifications. Because the aircraft was derived from a commercial airplane already in widespread use, this strategy was extended to aircrew training for the aircraft. American Airlines Training Corporation (AATC), as the successful bidder for the aircrew training system, was contracted to produce trained crew members for the Air Force. This was a departure from the current training contracting practices in which equipment and courseware were generally solicited separately. Under this new approach, responsibility for resources, material, equipment and personnel rested with the contractor. This approach has led to reduced overall costs for equipment, more effective integration of the training system, and reduced time to train.

The prime considerations from a contractual standpoint are the warranty and performance objectives. A key aspect of this approach was the commercial procurement of training devices and services through a single manager. The prime contractor, with sole contractual responsibility to the Air Force for the success of the program, guarantees the proficiency of graduating crew members to standards established by the Air Force. Final evaluations are performed by Air Force flight examiners in accordance with SACR 60–4, the results of which are not subject to dispute by the contractor. If an aircrew does not meet Air Force standards, additional training is provided at no additional cost until performance is acceptable.

In addition to warranties and performance objectives, specifications of this contract are also oriented toward "best commercial practices". Although most data items associated with the contract specify "contractor format acceptable", the actual DD Form 1664 preparation instructions specify MIL–STD 490 (Specification Practices) requirements. In other words, all product, software and development specifications meet the contract requirements outlined in the associated Military Standard 490 specification.

PROJECT 2363

Senator GOLDWATER. Please explain briefly Project 2363. When will an operational 2363 visual system be available?

General WILLIAMS. This project provides for the development, installation, demonstration, and testing of advanced visual systems on the Advanced Simulator for Pilot Training (ASPT) at Williams, AFB, AZ. Simulator visual systems consist of two major components, the image generators (picture production) and the visual displays which present the visual image to the pilot. Adequate image generator systems should be demonstrated on Project 2363 in 1984. The visual display, however, continues to present serious performance problems for the tactical fighter simulation. Such fighter training requires highly detailed complex visual scenes which are displayed over a very large field of view. Resolutions approaching the limit of human vision and brightness sufficient to see distant targets while they are still small in visual size are required. We anticipate that by 1987, a large field of view dome display with sufficient resolution and brightness will be demonstrated under Project 2363. We are also, under this project and in conjunction with the Canadian Government, developing a fibre optic helmet mounted display system which has considerable promise for this application at greatly reduced cost, should the technology prove feasible.

FIVE-YEAR FUNDING PROFILE FOR PROJECT 2363

Senator GOLDWATER. Provide the projected 5-year funding profile for Project 2363. If Project 2363 were to be considered "adequately" funded, what would that level of funding be? Provide a funding profile for fiscal year that shows the ideal of funding?

General WILLIAMS. The projected 5-year (fiscal year 1985–89) funding profile for Project 2363 is as follows (TY$M):

Fiscal year:	*Millions*
1985	$5.960
1986	3.130
1987	3.100
1988	3.300
1989	3.900

This project has been structured to accommodate those tasks necessary to adequately demonstrate and evaluate a tactical visual system. We believe, therefore, the profile requested is adequate.

COMMERCIAL VERSUS MILITARY STANDARDS FOR FLIGHT SIMULATORS

Senator GOLDWATER. What is the approximate difference in the cost between a flight simulator built to commercial standards and one built to military standards? What accounts for the difference? Is the additional cost justified?

General WILLIAMS. There are two primary reasons for cost differences between simulators built to military versus commercial standards. The major difference between the two is that commercial simulators are built to perform in a flight envelope well within the normal operating limits of the aircraft. Military flight simulators for combat aircraft operate at the extremes of and even outside the flight envelope. For example, because our fighter pilots frequently operate near the outer limits of controlled flight, there can be a thin margin between normal fighter maneuvering and unintentional, uncontrolled flight. Intentionally entering and recovering from uncontrolled flight is practiced only in a simulator. This enhances flying safety. Certain combat tasks, such as analyzing threat radar emissions on a radar warning receiver and taking proper action, can generally be practiced only in a simulator. This enhances training effectiveness. We believe the additional costs required to adequately simulate these areas and to ensure correlation between the more complex avionics are justified based on improved flying safety, reduced aircraft attrition and increased training effectiveness. Secondly, there are also cost differences between more directly comparable military airlift aircraft and commercial aircraft due to management practices. Our studies indicate up to $6.3 million in additional acquisition costs and varying amounts in support costs for comparable military commercial simulators. The acquisition costs are driven primarily by larger manufacturer program teams, longer military development schedules, and greater data requirements. Spares costs are driven primarily by pipeline spares and provisioning data. We are taking a number of actions to reduce these costs. They include increased reliance on competitive acquisitions, baselining simulator programs, increased use of contractor logistics support, greater use of warranties, early implementation of a common computer language (ADA), and modular designs.

IMPROVEMENT IN MILITARY SIMULATORS

Senator GOLDWATER. What improvements in reliability, maintainability, and availability are expected in flight simulators built to military specifications rather than to commercial specifications?

General WILLIAMS. Very little. Availability rates for commercial simulators today are generally equal to military rates for similar systems.

OPERATIONAL FLIGHT SIMULATORS RATES

Senator GOLDWATER. Please provide the actual availability and utilization rates of your operational flight simulators, and compare them with the availability rates that were designed into these simulators. This data should be provided on a monthly average basis for the past 3 years.

General WILLIAMS. Actual availability and utilization data on a monthly average basis for the past 3 years is not readily available. A data base is currently being developed to obtain actual rates by types of simulators. Availability rates were not used in design specification of previously acquired simulators. An availability rate of approximately 95 percent is being included in design specifications of current acquisitions.

CONTRACTOR MAINTENANCE FOR FLIGHT SIMULATORS

Senator GOLDWATER. What percentage of Air Force operational flight simulators are maintained by contractors? How does the cost of contractor support flight simulators compare with the cost of Air Force support?

General WILLIAMS. Currently, approximately 5 percent of the Air Force's flight simulators are maintained by contractors. The majority of these are Undergraduate Pilot Training—Instrument Flight Simulators (UPT-IFS) which are maintained by contractors via bid maintenance service contracts. Reviews have indicated that these are cost effective means of maintaining the UPT-IFS. Cost comparisions conducted for the operator functions at four locations have shown that contract costs are 7 percent less expensive than in-house operations. The B-52 Weapon System Trainers (WST) have been maintained by the original design contractor during the

fiscal year 1983 and 1984 scheduled delivery period. The Air Force is currently in the process of awarding a competitive bid contract for B-52 WST support.

AVAILABILITY FOR TRAINING OF FLIGHT SIMULATORS

Senator GOLDWATER. What are the reasons for any differences between the availability for training of flight simulators that are maintained by military personnel compared with those maintained by a contractor?

General WILLIAMS. There is no firm data to illustrate differences in availability rates between commercially maintained versus those maintained by Air Force personnel.

PLATFORM MOTION IN FLIGHT SIMULATORS

Senator GOLDWATER. What is the Air Force's assessment of the value of platform motion in flight simulators? What is the approximate cost of this feature? Which simulators currently under development will incorporate platform motion?

General WILLIAMS. 1. Our policy is to assess the value of platform motion case-by-case, based on merit. Following this policy, we are not using platform motion in any of our fighter developments. We are putting motion on the B-1B Weapon System Trainer (WST) and the C-5 Aircrew Training System currently under development. While studies attempting to demonstrate the transfer of training achieved from motion are inconclusive, they predominantly investigated pilot-induced motion cues in stable, easy to control aircraft, operating well within the normal flight envelope. The few studies that have addressed externally induced motion cues, such as battle damage or engine failure, have shown that motion under these circumstances produces performance more like that experienced in the aircraft and thus provides more realistic aircrew training. Since military aircraft are frequently operated at the extremes of the flight envelope and in hostile environments, these are often the more relevant studies for our purposes. For example, in the B-1B WST, the crew will still have motion cues in the closed curtain environment, and the aircrew will be able to feel the results of a hit by a missile or an engine failure as well as see the results on instruments. Although we believe motion, where prudently used, enhances mission effectiveness and flight safety, we are requesting the Defense Science Board conduct a study on the value of motion for given tasks, for tanker, transport, and bomber aircraft to ensure these funds are being appropriately invested.

2. Approximate cost of platform motion per unit ($FY85):

[In thousands of dollars]

	6 degrees of freedom	3 degrees of freedom
Hardware	$600–$700	$400–$500
Nonrecurring	50	50

3. The B-1B WST, C-5 ATS, and HH-60A will incorporate platform motion.

TRANSLUCENCY IN SIMULATOR VISUAL SYSTEM

Senator GOLDWATER. How will translucency be utilized in simulator visual systems? If translucence capability already has been utilized, what has been the payoff in terms of training transfer? Is the training transfer anticipated from the added capability of translucency worth the cost?

General WILLIAMS. Translucency, in terms of visual simulation, is a function of the computer generated image software which allows the aircrew member to "see through" elements in the visual scene. This includes "seeing" a pilot inside a cockpit in formation or air-to-air combat, a runway through haze or light clouds, or terrain through trees where background is an important element of visual scene realism.

Translucency is being used to reduce the complexity of individual items and to increase the fidelity of the visual scene. Translucency is being applied in some Air Force visual systems, for example to allow pilots to see through a canopy or to fade objects in and out of the visual scene. This is a present technology capability.

Project 2363 will allow additional uses of translucency to increase fidelity. Such uses include seeing background areas (e.g., terrain or sky) behind a tree.

Because this is a relatively new capability, the Air Force has no objective results in specific terms of training transfer. Increases in fidelity of the visual scene, however, suggest higher levels of training effectiveness for systems which have or will have translucency as part of the visual system.

DEFENSE SCIENCE BOARD STUDY

Senator GOLDWATER. The Defense Science Board recently conducted a study to determine how effective our simulator technology efforts have been in the past and to determine where our future efforts should take us. Please provide for the record a summary of this report as it applies to Air Force Flight simulators.

General WILLIAMS. The Defense Science Board (DSB) recommendations impacted Air Force flight simulators in two principal areas.

a. To determine simulator fidelity to meet specific training requirements, and

b. If cost effective, to get that fidelity to the user as soon as possible.

To answer these recommendations, the Air Force is pursuing several initiatives, many of which were on-going projects prior to the DSB recommendations. Specific areas of research include:

a. Low level awareness training.

b. Optical flow/texture variables (Visual).

c. Task loading during combat operations.

d. Model Aircrew Training System.

e. Project 2363—Advanced Visual Technology System.

f. Performance Measurement System.

g. Training Effectiveness Data Base.

Each of these have resulted in products which have been or will be implemented in existing training systems or simulators.

As an example, Project 2363, Advanced Visual Technology Systems, is the development phase for a cost effective, high training capability visual system for simulator applications for the Air Force and Army. Part of this development is a training effectiveness study which will provide data for further refining the training efficiency and cost effectiveness of visual systems.

In order to ensure that cost effective training systems are supplied to the aircrew members, the Air Force has revised its simulator policy (April 1984) and the implementing directive AFR 50-11, Management of Training Systems (August 1984). These documents emphasize training system justification, reduction of sophistication where possible, provision for safety-of-flight simulators prior to delivery of the weapon system, and a new approach to modification of simulators to help insure concurrency of the simulator with the weapon system.

COOPERATIVE EFFORTS WITH NAVY

Senator GOLDWATER. To what extent has the Air Force participated in cooperative efforts with the Navy to develop simulator technology?

General WILLIAMS. The Air Force has participated or initiated efforts with the Navy (and the Army) in the development of simulator technology in the following areas:

a. Standard DOD programming language (ADA). Since ADA will be a mandatory requirement in future simulator development programs, we have developed a Memorandum of Agreement for the Army, Navy, and Air Force to develop a common approach. The three services, through the Interservice/National Security Industrial Association (NSIA) Simulation and Training Working Group, will focus on training and ADA implementation methodologies, with the goal of implementing ADA on all new training device procurements by 1987.

b. Software Development Standards. We participate with the Navy, through the Joint Logistics Commanders, in the review and exchange of requirements with the intent of developing standard software development standards and data item descriptions.

c. Data Base Transformation Programs. The digital data base provided by the Defense Mapping Agency requires pre-processing prior to use for sensor simulation, such as digital radar or visual scene representations. The Air Force is lead on a joint effort with the Navy and Army for the development of a Standard Simulator Data Base/Common Transformation Program that will be used by the three services.

d. Instructor/Operator Stations. The Instructor-Operator Station (IOS) for any aircrew training device is a large driver of computer resources and operator training. The Air Force is proposing to work jointly with the Navy (with Army endorsement) to develop a generic IOS software model for all training devices. This will allow

standardization of the operator interface, reduce operator training, standardize definition of control functions, and overall provide a data driven module which will reduce computational requirements and develop costs.

e. Instructional System Development. The Navy recently provided the Air Force the software for their computerized Instructural Systems Development (ISD) program (called CASDAT, for Computer Aided System for Development of Aircrew Training). We are currently rehosting this program on our computers for Air Force use.

f. Technology–Modernization. We have initiated a tri-service coordinated effort to identify technology-modernization (industrial modernization) candidates.

g. Software Quality Assurance. We have initiated a tri-service effort to improve software quality assurance management, acquisition practices and contract administration.

h. Certifiable Configuration Management Procedures. We have initiated a tri-service effort, along with Singer-Link, to develop configuration management procedures that are certifiable (similar to the cost reporting systems certifications).

i. Modularity. The Army, Navy, and Air Force are exploring modular simulator design concepts for future acquisitions. A Joint Logistics Commander sponsored working group has been established to facilitate the exchange of information among the services.

j. Visual Simulation. The Eye-Slaved Display Integration and Test (EDIT) program is a joint Navy and Air Force study to develop a full field of view visual display for simulators. The Army is supporting the Air Force Project 2363, Advanced Technology Visual System, with additional funding to develop enhanced visual scenes.

k. Cost Analysis. We are working with the Navy to find ways of better storing and retrieving data for cost analysis.

TDAC

Senator GOLDWATER. The Training Data and Analysis Center (TDAC) was recently formed by DOD to centralize and coordinate training and training systems information. Since TDAC will study training effectiveness issues, will this not be a redundancy of efforts since the HRL is the lead DOD laboratory for collecting and analyzing training data?

General WILLIAMS. The Defense Training Data and Analysis Center (TDAC) will study training effectiveness issues based on OSD or Service identified requirements which have not been satisfied through other agencies. The TDAC's method of operation will be to first ascertain that data is or is not available from other sources. Should complete or partial data be available, these data would be used. Data collection would not be duplicated. As a point of information, the HRL is not designed as the lead DOD laboratory for collecting and analyzing training data. Part of the rationale for establishing the TDAC was the lack of a DOD focal point for collecting and analyzing training data; a task done currently by the individual services primarily through the Army Training and Doctrine Command (TRADOC), the Navy Chief of Naval Education and Training (CNET) and the Air Force Air Training Command (ATC). The TDAC is not primarily a research organization, as are the DOD laboratories, but will deal primarily with the effective application of training resources.

BEST COMMERCIAL PRACTICES

Senator GOLDWATER. What studies are available which address the issue of "best commercial practices" versus military procurement. Please provide copies of these studies to the Committee and provide a summary of conclusions of these reports so that they may be made a part of this report.

General WILLIAMS. The KC–10 Follow-on Aircrew Training Organic versus Contract Support Cost Study addressed this issue and is attached. The results of this study indicate contract support to be a more cost-effective training alternative for the KC–10 program. There is no "crossover" point within the projected KC–10 fleet size of 60 aircraft. The overall results of this study revalidate the earlier Air Force decision to employ contractor supported aircrew training for the KC–10 program.

KC-10 FOLLOW-ON AIRCREW TRAINING
ORGANIC VS CONTRACT SUPPORT
COST STUDY

PROGRAM CONTROL DIVISION
DIRECTORATE OF KC-10
DEPUTY FOR AIRLIFT AND TRAINER SYSTEMS
AERONAUTICAL SYSTEMS DIVISION
WRIGHT-PATTERSON AFB, OHIO 45433

15 SEPTEMBER 1982

KC-10 FOLLOW-ON AIRCREW TRAINING
ORGANIC VS. CONTRACT SUPPORT
COST STUDY

EXECUTIVE SUMMARY

A. The KC-10 Follow-On Aircrew Training (FOAT) Organic vs. Contract Support Cost Study is submitted in response to PMD No. R-5010(16)/27222F. The purpose of this study is to comply with this directive which states: "... A determination of the force size at which it becomes cost-effective to establish and operate an organic capability for the KC-10 aircrew training will be made."

B. In response to this direction, cost projections were made considering various combinations of organic and contract support, changing crew ratios, and differing acquisition assumptions to support a fleet of sixty aircraft.

C. The current KC-10 FOAT contract provides firm-fixed prices for complete KC-10 aircrew training through FY 85; the contract is redeterminable on a firm-fixed price basis beyond FY 85 and through FY 93. Contract support costs were developed directly from the contract matrix. The formulation of organic support cost estimates involved the use of the most currect cost estimating models available, inputs from industry experts, and KC-10 Program Office estimates.

D. All cost estimates were developed for a twenty year "steady state" system (i.e., no "phase-in" or "phase-out"). In addition, only those Operations and Support (O&S) costs affected by the contract vs organic support decision were included in this analysis. Results are summarized below.

FOAT SUMMARY COST COMPARISONS

(FY 80 $, in Millions, 20 years)

	TOTAL CONTRACT	TOTAL ORGANIC
3:1 CREW RATIO	$ 134.0	$ 227.8
4:1 CREW RATIO	178.5	261.6

E. These results clearly indicate no logistics support "crossover" point within the parameters considered. Study results also show no mix of contract and organic support to be more cost-effective than the total contract support now employed. Based on cost considerations, this study clearly indicates contract support as being advantageous to the Air Force for the forseeable future.

KC-10 ORGANIC VERSUS CONTRACT SUPPORT
FOLLOW-ON AIRCREW TRAINING
COST STUDY

I. Background

A. The United States Air Force awarded the KC-10A Follow-On Aircrew Training (FOAT) contract to American Airlines, Inc., on 15 July 1980. The KC-10 program is based on taking maximum advantage of the existing commercial developments of wide-bodied freighter aircraft and the support thereof. This philosophy avoids the high RDT&E costs normally associated with the acquisition of a new weapon system. As such, the program is structured to take advantage of the established commercial logistics support base and commercial practices, including FOAT.

B. Due to changing parameters, a need has arisen to reevaluate this training philosophy. Program Management Directive number R-P5010(16)/27222F of 29 MAR 82 [para 3.a.(e)] states:

> "... A determination of the force size at which it becomes cost effective to establish and operate an organic capability for the KC-10 aircrew training will be made. If this point falls within the 60 (57 PAA) KC-10 force size contained in the FY 83 President's Budget, a proposed implementation plan will be developed for presentation to the Air Staff." [para 3.a.(e)]

II. Assumptions

A. Prices for training crews in a four-to-one crew-to-aircraft ratio ("4:1 crew ratio") were projected from contract prices in the existing Unit Price Matrix (UPM). (The UPM is currently structured for a 3:1 crew ratio.)

B. The contractor will have the capability to train and maintain the combat readiness of aircrews in the 4:1 ratio by FY 87. (A 4:1 crew ratio is necessary to support the proposed rate of 880 FH/PAA/YR.)

C. The KC-10 will continue to support the general purpose and airlift forces. There will be no primary SIOP involvement.

D. Hardware will continue to be acquired to commercial rather than military specifications. PMD number R-P5010/27222F requires maximum usage of commercial practices (para. 3). Rough-order-of-magnitude calculations (see Appendix A-2) validate the early Air Force decision and justifies continued pursuit of this acquisition concept.

E. Increasing crew ratio from 3:1 to 4:1 will not require acquisition of additional hardware.

F. System life is assumed to be twenty years. Estimates developed for this time-span assumed sixty aircraft at three main operating bases (MOBs) with a complete training system at each site.

III. Estimating Procedures

A. Most cost inputs to this study were available in FY 80 dollars; other costs were adjusted to FY 80 dollars. All cost estimates and conclusions, therefore, are presented in FY 80 dollars to maintain consistency.

B. Aircrew training and operations and support (O&S) cost estimates for both contract and organic alternatives were based on a twenty year "steady state" system life (i.e., no system "phase-in" or "phase-out").

C. Currently, the KC-10 FOAT contract is written to support the training of aircrews in a 3:1 ratio. Contract prices are projected to be 33.3% over and above the current UPM to support the proposed 4:1 crew ratio; this is the same method used for KC-10 budget submissions. (Purchase of additional training hardware is not considered necessary to support this 4:1 crew ratio.)

D. Organic cost estimates were derived from the ASD/YW Aircrew Training Device Life Cycle Cost Model (Version 9.0, 1 Jun 82). The analysis utilized design sensitive FY 79 logistics support contractor baseline inputs from the Singer-Link KC-135 Weapon System Trainer.

E. Common costs which would be identical under any alternative are not considered.

IV. Organic Cost Estimates

A. Aircrew Training: Estimation of organic aircrew training (follow-on only) was a two-step process. First, the required number of "blue-suit" instructors was estimated. Secondly, the "cradle-to-grave" costs of these instructors were estimated using factors from AFR 173-13, USAF Cost and Planning Factors. Resulting estimates are summarized in Table 1 and detailed in Appendix B-1.

Table 1

ORGANIC AIRCREW TRAINING

(FY 80 $, in Millions, 20 years, 3 MOBs)

	CREW RATIO	
	3:1	4:1
TOTAL	$101.4	$135.2

B. Operations and Support (O&S): Organic O&S costs were estimated using the ASD/YW (SIMSPO) Aircrew Training Device Life Cycle Cost Model (Version 9.0 of 1 Jun 82). Currently, no contractual provisions exist for the Air Force to assume O&S responsibilities. Rough-order-of-magnitude estimates for acquiring the necessary O&S data range between three and five million dollars (not included below). Organic O&S cost estimates are presented in Table 2 and detailed in Appendix B-2.

Table 2

ORGANIC OPERATIONS AND SUPPORT

(FY 80$ in Millions, 20 Years, 3 MOBs)

	CREW RATIO	
	3:1	4:1
TOTAL	$125.1	$125.1

NOTE: Does not include O&S data costs

C. Option 5: Air Force assumption of training responsibilities would require the exercise of "Contract Option 5." This is a one-time charge; see Table 3.

Table 3

OPTION 5

(FY 80 $, in Millions, 3 MOBs)

TOTAL	$ 1.3

V. Contract Cost Estimates

A. General: The FOAT contract F33700-80-C-0040 is composed of six parts: a basic contract with five options. Option 1 deals with interim aircrew training. Option 2 pertains to training device acquisition; this was addressed earlier. Since this study is concerned with a "steady state" training program, Option 3 will be used for consideration of all direct follow-on aircrew training costs (i.e., Option 1 will not be considered). Option 4, operations and support (O&S), is also addressed in this section. Finally, Option 5 was considered in section IV. Option 5 would only be exercised should the Air Force choose to implement organic follow-on aircrew training, hence its inclusion under organic costs.

B. Basic Contract: Generally, the services and training device(s) provided by the contractor shall involve the full spectrum of KC-10A aircrew training requirements. These include curriculum development, data development and management, software development and maintenance, acquisition of training

devices, training devices/site maintenance, and support operation and aircrew training (interim and complete). The following tasks will be performed throughout the life of the contract:

(1) Guaranteed Aircrew Qualification Level

(2) Task and Media Analysis

(3) Program Review Conferences

(4) Communications Support

(5) Data Management Support

C. Aircrew Training (Option 3): Exercise of this contract option assures the Air Force of fully trained and qualified aircrews to support a 3:1 crew ratio. Option 3 provides all initial, refresher, and instructor training as required. Current contract prices only support training for a 3:1 crew ratio. These prices are multiplied by 133.3% to estimate suport costs of a 4:1 crew ratio. Table 4 summarizes these costs; details are in Appendix C-1.

Table 4

OPTION 3: AIRCREW TRAINING

(BY 80 $, in Millions, 20 years, 3 MOBs)

	CREW RATIO	
	3:1	4:1
TOTAL	$ 84.5	$112.6

D. Operation and Support (Option 4): Exercise of Option 4 provides the Air Force with total contractor support of all O&S tasks. Organizational, intermediate, and depot level maintenance are included; facilities maintenance is excluded. Estimated Option 4 costs (in FY 80 $) are summarized in Table 5; details are in Appendix C-2.

Table 5

OPTION 4: OPERATIONS AND SUPPORT

(BY 80 $, in Millions, 20 years, 3 MOBs)

	CREW RATIO	
	3:1	4:1
TOTAL	$ 49.5	$ 65.9

VI. Cost Comparisons and Analysis

A. Table 6 lists the cost elements specifically included and excluded from the study.

Table 6

KC-10 FOAT ORGANIC VS CONTRACT SUPPORT COST STUDY
COST ELEMENTS

CONTRACT	ORGANIC
AIRCREW TRAINING -Option 3	AIRCREW TRAINING -Pay -Personnel Acquisition -Training -Installation Support -Base Ops. Support
OPERATIONS & SUPPORT -Option 4	OPERATIONS & SUPPORT -Pay -Personnel Acquisition -Training -Installation Support -Base Ops. Support -Depot Maintenance -Sustaining Investment -Indirect Support -Depot Non-Maintenance
OTHER -None	OTHER -Option 5

COMMON ELEMENTS EXCLUDED

MODIFICATIONS
SIMULATOR OVERHEAD
FACILITIES
POWER
POL

The common elements idendified inside the heavy lines are costs considered to be constant regardless of support or training concept. In order to focus attention on the costs affected by the contract versus organic decision, these costs have been eliminated from the comparative analysis which follows.

B. Organic versus Contract Cost Element Comparisons: The following cost estimates are in FY 80 dollars, in millions rounded to the nearest tenth, except as noted.

Table 7

SUMMARY COST COMPARISON: 3:1 CREW RATIO

(FY 80 $, in Millions, 20 years)

CONTRACT		ORGANIC	
Aircrew Training (OPT 3)	$ 84.5	Aircrew Training	$101.4
Operations & Support (OPT 4)	49.5	Operations & Support	125.1
Other	--	Other (OPT 5)	1.3
TOTALS	$134.0		$227.8
PER CREW*	$204.0 K		$346.7 K

Table 8

SUMMARY COST COMPARISON: 4:1 CREW RATIO

(FY 80 $, in Millions, 20 years)

CONTRACT		ORGANIC	
Aircrew Training (OPT 3)	$112.6	Aircrew Training	$135.2
Operations & Support (OPT 4)	65.9	Operations & Support	125.1
Other	--	Other (OPT 5)	1.3
TOTALS	$178.5		$261.6
PER CREW*	$203.8 K		$298.6 K

* Crew ratios are discussed in Appendix A-3.

VII. Other Considerations

A. Due to the firm-fixed price nature of the FOAT contract, a high degree of confidence exists in the current and future contract prices. Firm-fixed prices beyond FY 85 can be redetermined by mutual agreement during a "redetermination period." Upon failure to reach such an agreement, the Government has the right to unilaterally exercise the next prospective FY price subject to adjustment (if appropriate) based upon fluctuation of the Economic Price Index. Organic costs, however, are less certain because they are only estimates.

B. With the FOAT contract, the contractor guarantees that aircrew graduates of its ground-based training course will meet mission qualification levels as set forth by the user. If any aircrew graduates should subsequently fail a standardization evaluation, the contractor is responsible for retraining at no additional cost to the Government. This end product guarantee of qualified aircrew members is a tremendous incentive for the contractor to develop and maintain a quality training program.

C. Another consideration is the length of time required to bring a training system on line. The contractor can have a KC-10A simulator system operational in 24 months compared to the estimated 30 months required for a simulator system built to military specifications. This reduces the length of time by 20%. With the present rate of aircraft deliveries, the earlier ready-for-training (RFT) date capability of the contractor is a very important consideration. In addition, the cost of a simulator built to military specifications is estimated to be 200 to 240 percent higher than a simulator built to commercial specifications. (See Appendix A-2 for cost comparison.)

VIII. Conclusions

A. The results of this study indicate contract support to be the more cost-effective alternative. There is no "crossover" point within the crew ratios considered. Furthermore, we do not expect such a "crossover" point to be reached before a crew ratio of at least 6:1 given a fleet of sixty aircraft (57 PAA).

B. The contractor has total responsibility for all KC-10 follow-on aircrew training and system maintenance (O&S). The inherent economies of scale of contract support, plus the non-flying status of contractor instructors make it more cost-effective than organic support. Comparisons with the organic training programs of other weapon systems also supported this conclusion (see Appendix D-1). The overall results of this study revalidates the earlier Air Force decision to employ a contractor supported follow-on aircrew training program.

APPENDIX A-1

Contributors

HQ USAF/ACM

HQ SAC/ACM

HQ MAC/ACM

HQ ATC/ACM

HQ ASD/AFYP

HQ ASD/AFYB

HQ ASD/ACCL

HQ ASD/YWP

HQ AFALD/PTL

4235 STS

American Airlines, Inc.

APPENDIX A-2

Hardware Acquisition

A. Aircrew training devices (ATD) acquired for support of the KC-10A aircrew training program are built to commercial specifications. If military specifications were applied instead, industry experts estimated "bottom line" prices would rise by a factor of 2 to 2.4. Rough-order-of-magnitude (ROM) price comparisions of the KC-10A operational flight simulator with similar, though not identical, systems for the C-130E and B-1B bore this out:

SIMULATOR SYSTEM R-O-M PRICE COMPARISONS

(FY 80 $, in Millions)

	KC-10A (firm)	C-130E (est.)	B-1B (est.)
R&D Unit	--	$44.6	$29.7
Production Unit	$13.8*	$26.1	$24.2

*Includes elements of non-recurring and initial spares costs

B. The basic cost figures for the C-130E and B-1B simulators were provided by ASD/YW (SIMSPO). Factors were added by the KC-10 program office as follows:

General and Administrative	17%
Profit	14%
Mission Support	4%
Engineering Change Orders	10%

Conclusion: It is not cost-effective to acquire KC-10A ATD's built to military specifications.

APPENDIX A-3

Crew Ratio

A. A "crew ratio" is the total number of active and reserve crews (including instructor pilots, etc.) maintained per Primary Aircraft Authorization (PAA). Two distinct crew ratios were considered in this study: three-to-one (3:1) and four-to-one (4:1). Calculations for total crews trained over the twenty year life cycle are detailed below:

	3:1		4:1	
PAA Supported	57		57	
x Crew Ratio	x3		x4	
Subtotal--Constant Force Size		171		228
x Annual Turnover Rate	x.142		x.142	
x Twenty Years	x 20		x 20	
Subtotal--Total Turnover		486		648
TOTAL CREWS TRAINED OVER SYSTEM LIFE		657		876

B. Crew ratios are submitted by Major Commands and approved or modified as appropriate by the Air Staff office of primary responsibility. In general, crew ratios are based on:

(1) Combat readiness requirements;
(2) Aircrew mission qualification;
(3) Lead time required to adjust acquisition and training of aircrews;
(4) Operational requirements such as type of aircraft and unique mission requirements (nighttime, daytime, 24-hour alert, turnaround time, etc.);
(5) Estimates of time lost due to sickness, leave, TDY, or other causes; crew ratios do not consider aircrew attrition for normal operations.

APPENDIX B-1

Organic Cost Estimate: Aircrew Training

A. To support a 3:1 crew ratio, we estimated the need (for each simulator system) for twenty instructors: ten instructor pilots and ten instructor flight engineers. This estimate was based on historical experience of the C-141 training program and KC-10 program office calculations. (Boom operator part task trainer instructors are not included since they are not used in the C-141 program comparison. If they were considered, the total cost for organic training would be much higher.) Other cost factors were used per AFR 173-13.

B. Acquisition of twenty instructors per simulator system is assumed to cause an increase in manning levels by the same amount. Consequently, this study considers the additional ("delta") costs of acquiring twenty additional instructors at each of three Main Operating Bases (total of sixty instructors).

ORGANIC AIRCREW TRAINING

(FY 80 $, in Millions, 20 instructors, life cycle)

Pay	$11.0
UPT/UNT	9.1
Retired Pay	5.4
FOAT	3.7
Personnel Acq.	2.0
Instl. Support Persn.	1.5
Base Ops. Support	.7
PCS	.4
Subtotal	33.8
x3 Main Op. Bases	x3
TOTAL	$ 101.4

C. To estimate costs to support a 4:1 crew ratio, the above TOTAL is multiplied by 133.3%. Costs for instructors maintaining "currency" are not considered in these estimates, since the instructors are considered to be "available" to fly the aircraft in contingencies.

APPENDIX B-2

Organic Cost Estimate: O&S

A. The SIMSPO ATD life cycle cost model used for this estimate utilizes design sensitive FY 79 LSC baseline inputs from the Singer-Link KC-135 weapon system trainer. The scheduled system operation is 112 hours per week with 31 assigned maintenance personnel. Increasing the crew ratio to 4:1 is assumed to entail no additional costs. Results are summarized below; the cost element output is reproduced on the next page.

ORGANIC OPERATIONS AND SUPPORT

(FY 80 $, in Millions, 20 years)

WBS Element*		
2.1	Unit Mission Pers. (Maint.)	$14.1
2.2	Unit Consumption	2.7
2.3	Depot Maintenance	9.5
2.4	Sustaining Investment	2.8
2.5	Installation Support Personnel	2.3
2.6	Indirect Support	1.6
2.7	Depot Non-Maintenance	4.9
2.8	Personnel Acquisition/Training	3.8
		41.7
	x3 Main Operating Bases	x3
2.0	TOTAL	$ 125.1

*Work Breakdown Structure reference--see printout next page.

B. The following cost elements were not included in the organic O&S analysis (see printout reproduction next page):

2.1.2.4 Simulator Overhead
2.5.3 Modifications

These cost elements were considered "common" to any alternative--hence their exclusion. After deleting these elements, the "first-level" cost summaries in the printout can be multiplied by twenty; this generates the life cycle cost elements listed above.

2.0 OPER & SUPPRT	3.667
2.1 UNIT MSN-PRS	.729
2.1.1 INSTRUCTORS	0.000
2.1.2 MAINTENANCE	.729
2.1.2.1ORG MAINT	.404
2.1.2.2BASE SHOP	.232
2.1.2.3SOFTWARE	.067
2.1.2.4SIM OVRHD	.026
2.2 CONT UNIT SP	0.000
2.3 UNIT CONSUMP	.134
2.3.1 POWER	0.000
2.3.2 MAINT MATRL	.134
2.4 DEPOT MAINT	.475
2.4.1 SIMULATOR	.475
2.4.2 SIM SPPT EQ	0.000
2.4.3 SOFTWARE	0.000
2.5 SUSTNG INVST	1.716
2.5.1 REPLEN SPRS	.037
2.5.2 REPLACE SE	.100
2.5.3 MODS	1.578
2.6 INSTL SPPT PRS	.115
2.6.1 BASE OPR SP	.099
2.6.2 REAL PR MNT	.005
2.6.3 MEDICAL	.010
2.7 INDIRECT SPPT	.082
2.7.1 MISC O & M	.062
2.7.2 PCS	.020
2.8DEPOT NON-MAINT	.244
2.8.1 DEPOT SUPPL	.235
2.8.2 2ND DST TNS	.009
2.9 PERS A3N/TNG	.192
2.9.1 ACQUISITION	.032
2.9.2 TRAINING	.161
2.10 CONTR SUPPT	0.000
2.10.1 ICS	0.000
2.10.2 CS/PA	0.000
2.10.3 CLS	0.000

APPENDIX C-1

Contract Aircrew Training (Option 3)

A. Option 3 contract prices are firm-fixed price for FY 80 through FY 85. The FY 85 contract price was selected for estimating total life cycle aircrew training costs. We considered this to most nearly approximate a "steady state" training system.

B. Factors for developing "prospective prices" for FY 86 through FY 93 are also provided in the contract. These factors were used to obtain a FY 85 to FY 80 de-escalator using log-linear regression. Computations are detailed below:

CONTRACT AIRCREW TRAINING

(FY 80 $, in Thousands, 20 years)

Option 3--FY 85 $	2,845.0
x FY 85 to FY 80 de-escalator	x .49485
Option 3--FY 80 $	1,407.8
x 3 Main Operating Bases	x 3
x 20 years	x 20
TOTAL	$ 84,468.0

C. To support a 4:1 crew ratio, the TOTAL is multiplied by 133.3%.

APPENDIX C-2

Contract O&S (Option 4)

A. Identical logic was used for genertating Option 4 estimates as was used for Option 3 (see Appendix C-1).

CONTRACT O&S

(FY 80 $, in Thousands, 20 years)

Option 4--FY 85 $	$ 1,665.9
x FY 85 to FY 80 de-escalator	x .49485
Option 4--FY 80 $	824.4
x 3 Main Operating Bases	x 3
x 20 years	x 20
TOTAL	$ 49,464.0

B. To support a 4:1 crew ratio, the TOTAL is multiplied by 133.3%.

APPENDIX D-1

Other Comparisons

A. In the course of conducting this study, comparisons of training costs between various systems were accomplished. These are detailed below:

FOAT: SYSTEM COMPARISONS

(Initial Qual. only, full crew, FY 80 $, in Thousands)

Aircraft	Total	= Non-Flying	+ Flying
KC-10	$ 170.0	$ 64.9 (38%)	$ 105.1 (62%) [POL: $84.9 (81%)]
C-5	538.9	147.7 (37%)	391.2 (63%) [POL: $181.6 (46%)]
C-141	209.1	101.9 (49%)	107.2 (51%) [POL: $79.0 (74%)]
KC-135	376.9	116.5 (31%)	260.4 (69%) [POL: $191.0 (73%)]

B. KC-10 costs include:

Flying Hour Costs
- -POL
- -Contractor Log Support
  - --A/C Maintenance
  - --FOAT
- -Supplies

Non-Flying Costs
- -Base Operations Support
- -Staff Pay
- -Student Costs

C-5, C-141, and KC-135 costs include:

Flying Hour Costs
- -POL
- -Support Equipment
- -Materiel/Supplies
- -Replenishment Spares
- -Depot Maintenance

Non-Flying Costs
- -Base Operations Support
- -Staff Pay
- -Student Costs

NOTE: Command support pay, other indirect charges, and real property depreciation are not included in any figures.

CENTRAL MANAGEMENT OF SIMULATORS—ARMY

Senator GOLDWATER. What is being done in the Army, Navy, and Air Force to centralize management and accountability over the development and procurement of simulators?

General KENYON. The Army's major system Program Managers retain overall responsibility for all aspects of their programs to include simulators. Because of the technical nature and high cost of simulators, the Army has chartered the Program Manager for Training Devices (PM-TRADE) to develop and procure these for the system program manager.

DELIVERING SIMULATORS

Senator GOLDWATER. Should the first simulator for a major weapon system be planned for delivery before or after the delivery date of the actual weapon system?

General KENYON. While the decision must be made on a system by system basis, in general the first simulator for a major weapon system should be planned for delivery before the delivery date of the actual weapon system.

Senator GOLDWATER. What is the current practice?

General KENYON. Currently we are striving to meet the objective of delivering simulators before delivery of the system. In the Light Family of Helicopters (LHX) program our goal is to deliver the training simulator one year prior to the first unit equipped date of the aircraft.

Senator GOLDWATER. What benefits would you expect to realize from delivering the first simulator ahead of the weapon system?

General KENYON. The most obvious benefit of having the simulator available ahead of the weapon system is that effective hands-on-training can be conducted. As a result, individuals would be well on their way to achieving proficiency with the system even before it is fielded. Earlier unit readiness would then naturally fall out as a second major benefit. A third benefit is crew safety. The capability to train in a simulator would lower accident rates caused by unfamiliarity with the primary piece of equipment.

Senator GOLDWATER. How many different flight simulators does the Army have in production or development? Please list these.

General KENYON. The Army has three simulators in production and one in engineering development. They are:

Type simulator	Phase	Status
CH-47C (CHINOOK)	Production	Being fielded.
AH-1S (COBRA)	Production	Do.
UH-60 (BLACK HAWK)	Production	Awaiting contract award.
AH-64 (APACHE)	Engineering development	Manufacturing.

SIMULATOR AUTHORIZATION COST

Senator GOLDWATER. Provide the total authorization requested in fiscal year 1985 for each of the following: flight simulators; other related training devices requiring authorization; modification for these devices; and R&D by program element and project.

General KENYON. The Army's President's Budget for Fiscal Year 1985 requested $169.2 million for procurement of nine flight simulators (2 AH-1; 4 UH-60; and 3 AH-64). An additional $6 million was requested to convert or modify one CH-47C model simulator to the "D" model configuration. The fiscal year 1985 requested included R&D funds as follows:

[In millions of dollars]

Program element	Project	Amount
63216A	DB34	3.285
63216A	DB39	5.808
64217A	D275	14.1

Other major categories of training devices requested in fiscal year 1985 are as follows:

[In millions of dollars]

Category	Procurement amount	RDTE amount
Nonsystem training devices	143.1	40.63
Armor	112.3	.....
Air Defense	23.4	.....
Missiles	47.1	.....
Chemical	1.2	2.0
Aviation	19.7	2.3
Commo-Electronics	25.2	24.2

5-YEAR DEFENSE PLAN

Senator GOLDWATER. Provide the same data for the five year defense plan.

General KENYON. The fiscal year 1985 President's budget five year defense plan includes the following:

[In millions of dollars]

	Fiscal year—			
	1986	1987	1988	1989
Procurement				
Flight simulators:				
UH–60	70.7	72.5	.....	.....
AH–64	70.0	17.6	.....	.....
Nonsystem training devices	119.2	209.7	215.8	212.9
Armor	139.3	.9	.9	1.4
Air Defense	3.1	5.8	.....	.....
Missiles	54.1	45.1	44.1	68.4
Chemical	2.4	2.5	1.1	.....
Aviation	10.3	6.0	10.2	4.3
Commo-Electronics	11.1	10.4	2.8	1.5
R&D				
Flight simulation:				
63216A DB34	3.3	1.6	1.9	1.2
63216A DB39	8.5	17.3	18.5	6.4
64217A D275	9.3	13.0	7.6	7.7
Nonsystem training devices	43.562	60.328	67.985	69.222
Armor	.....	.....	.....	.....
Air Defense	.....	.....	.....	.....
Missiles	.....	.....	.....	.....
Chemical	.4	1.7	2.1	.9
Aviation	3.8	4.5	3.6	26.1
Commo-Electronics	6.0	1.3	.....	.....

The five year defense plan reflects request for $8.2 million in fiscal year 1988 to begin modification/upgrade of the Army's fleet of UH–1 flight simulators.

SIMULATOR TRAINING AT FORT RUCKER

Senator GOLDWATER. Please provide a brief summary of the simulator training conducted at Fort Rucker.

General KENYON. Flight simulators (FS) currently used at the U.S. Army Aviation Center (USAAVNC) include the following:

	Cockpits
UH-1 flight simulator	32
CH-47 flight simulator	1
UH-60 flight simulator	2
AH-1 flight and weapons simulator (FWS) [1]	2

[1] One FWS systems.

The UH-1FS is used by students in the Initial Entry Rotary Wing Course, Aviator Refresher Course, Instrument Flight Examiners, Foreign Military, Instructor Pilot Training, active duty aviators stationed at USAAVNC, and Reserve Component personnel undergoing continuation training. A breakdown of hours flown in the UH-1FS during the first 11 months of Fiscal Year 1984 is as follows:

Program of instruction	61,297.9
Reserve components	2,419.1
Air crew training manual	12,467.9
Remedial	16,937.4
Total	93,122.3

The CH-47FS is used by students participating in the CH-47 Aircraft Qualification Course (AQC), CH-47 qualified aviators stationed at USAAVNC, and other CH-47 qualified aviators from the U.S. Army Forces Command (FORSCOM) units. It was flown a total of 2946.7 hours during the first 11 months of fiscal year 1984. CH-47 AQC program of instruction includes 18.2 hours in the flight simulator.

The UH-60FS is used by students in the UH-60 AQC, UH-60 aviators at Fort Rucker, and personnel from FORSCOM units undergoing continuation training. It was flown a total of 5014.7 hours during the first 11 months of fiscal year 1984. The POI for the UH-60 AQC requires 10.5 hours of flight instruction in the simulator for each student.

The AH-1FWS is undergoing upgrade from its previous AH-1Q configuration. The AH-1Q was flown 982.2 hours during the first four months of fiscal year 1984. Upgrade to AH-1S Fully Modernized configuration will be completed during October 1984. The AH-1FWS will be used 6 hours by each aviator going through the AH-1 AQC and by USAAVNC and Reserve Component AH-1 qualified aviators for continuation training.

USING SIMULATORS FOR FLIGHT TRAINING

Senator GOLDWATER. Are operational flight simulators being used to reduce flight training hours, or are they being used to reduce operational flying hours?

General KENYON. Operational flight simulators are being utilized to enhance institutional flight training and tasks that cannot be trained in the aircraft. Continuation training in flight simulators supplements training for the field commander to maintain pilots' combat mission proficiency under an already critically reduced flying hour program. Time flown in a flight simulator is logged against the pilots annual flight training requirement, not his operational flying hours.

AH-64 SIMULATORS

Senator GOLDWATER. What flight simulators are planned for the AH-64?

General KENYON. The Army intends to buy seven AH-64 Combat Mission Simulators (CMS). Of the seven CMS, the first is the prototype currently under development and scheduled for fielding and ready for training in 1985. The six production models will begin fielding in October 1986. The simulator is designed to train a pilot from aircraft transition to complete combat readiness, including weapons training and countermeasures training.

Senator GOLDWATER. What is the estimated cost and delivery schedule for these simulators?

General KENYON. The total cost of the simulator, which includes all Government Furnished Equipment (GFE), and maintenance contract is estimated to be $70.0 million. The delivery schedule for seven simulators is as follows:

Location and delivery date

Fort Rucker, Alabama, December 1985.
Fort Hood, Texas, August 1986.
Illesheim, Germany, November 1986.
Fort Campbell, Kentucky, September 1987.
Fort Bragg, North Carolina, December 1987.
Weisbaden, Germany, July 1988.
Hanau, Germany, November 1988.

The AH–64 Combat Mission Simulator production contract is in the final stages of negotiation. Therefore, unit cost for the production models is not firm. Funding profile for the production models is as follows:

Fiscal year:	*Million*
1984	$28.9
1985	63.4
1986	70.0
1987	*17.6

*Preplanned product improvements.

Senator GOLDWATER. Are they funded within the AH–64 program or in a separate account?

General KENYON. All prototype flight simulators are built as an engineering development effort in the Army's Research and Development program. The production model simulators are all funded under the budget item "Synthetic Flight Training Systems."

ARMY/CONTRACTOR SIMULATOR COST COMPARISON

Senator GOLDWATER. How does the cost of contractor support of flight simulators compare with the cost of Army support?

General KENYON. In 1979, a cost comparison study was done on Contractor versus Government maintenance support of flight simulators. This study covering the period 1981 through 2002, showed contractor maintenance cost less costly than government maintenance.

U–COFT

Senator GOLDWATER. What is the production contract status of the U–COFT? Provide a funding profile and acquisition schedule for this trainer.

General KENYON. The first three Lots have been awarded as Fixed Price Incentive (FPI) contracts. Lot IV will be awarded in May 1985 and the last Lot, Lot V will be awarded in May 1986. As stated in the fiscal year 1985 President's Budget the funding profile and acquisition schedule for the trainer is below:

CONDUCT OF FIRE TRAINER

[In millions of dollars]

	Lot I	II	III	IV	V			
	FY 1983 and prior		FY 1984	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989
M1	162.0		31.3	37.1	55.2	0.9	0.9	1.4
M2/3	45.4		60.3	56.5	95.0			
M60A3	15.0		12.1	18.7				
Total	222.4		103.7	112.3	150.2	.9	.9	1.4

MAINTENANCE

	Quantity				
	FY 1983 and prior	FY 1984	FY 1985	FY 1986	Total
M1	30	17	8	19	74
M1A1		3	7	8	18
M2/3	16	24	34	50	124
M60A3	4	9	8		21
Total	50	53	57	77	237

FULL CREW INTERACTION SIMULATOR

Senator GOLDWATER. The Committee has been advised that some foreign armies plan to buy tank trainers with "out-the-hatch" capabilities. This sounds similar to the Full Crew Interaction Simulator (FCIS) once considered by the Army. Does the Army plan to renew its plans for an FCIS? If so, will this be an expansion of U-COFT or a new procurement? Please provide a funding profile and acquisition schedule if you plan to pursue this program.

General KENYON. The Army evaluated existing tank gunnery simulators with the "out-the-hatch" capabilities and found that this capability was achieved by the use of a terrain model board for target presentation. Because of the limitations associated with this approach, such as only training stationary tank gunnery, the Arny has opted for the Conduct of Fire Trainer as its primary tank gunnery trainer and a package of training devices that append to actual tanks and target systems to provide "out-the-hatch" tank gunnery training. This package is called the Full Crew Interactive Trainer and will provide sustainment training in the field through the use of laser transmitters and receivers, and video systems. The Army plans to procure approximately 200 of the devices at the rate of one per each armor battalion. The funding profile is as follows:

Fiscal year—	*Millions*
1983 and prior	$3.0
1984	0
1985	15.0
1986	11.0
1987	7.8
1988	0
1989	8.7

U-COFTS

Senator GOLDWATER. Are there any plans to integrate U-COFTS so that they can perform team training against one another (as is presently done in some flight simulators)? Does this require a modification to existing U-COFTS or must new units be procured?

General KENYON. Not at this time. However, the Army is investigating the feasibility of expanding the Conduct of Fire Trainer (COFT) to provide platoon leader and platoon training. The platoon leader would be required to direct the actions of his own tank as well as those of the remainder of his platoon. This would require both software and hardware changes be made to the U-COFT.

PROGRAM ELEMENT (PE)

Senator GOLDWATER. Please describe the projects in Program Element 64722A, Education and Training, and explain how they relate to specific simulator programs.

General KENYON. The scope of currently planned efforts to be conducted in the Program Element (PE) does not directly relate to any specific current simulator programs. This tri-service program, for which the Army is the lead Service/Executive Agent, was established to provide for the development of prototype training systems of vastly increased capabilities which are efficient, standardized, and cost effective by exploiting mini-computer and solid state informational display technologies.

Technological advances in all the services will be taken advantage of to produce standardized devices (hardware) with service-peculiar software. The first effort to be undertaken is the development of a family of Portable Electronic Aids for Maintenance (PEAM) which will be employed not only as training aids, but also as job aids to assist the service member in performing maintenance. Future programs will be determined by a tri-service Steering Group which is so-chaired by the Office of the Under Secretary of Defense Research and Engineering and Office of the Assistant Secretary of Defense (Manpower, Installations and Logistics).

Senator GOLDWATER. Describe the projects in Program Element 64217, Synthetic Flight Training Systems. Is this Program Element devoted to the AH–64 WST, or are other projects included as well?

General KENYON. This Program Element supports the engineering development for building all prototype flight simulators. Gurrently, in addition to the AH–64 Combat Mission Simulator, it supports concept exploration efforts for the Aviation Combined Arms Team Trainer (ACATT) and the Light Helicopter Family (LHX) flight simulator.

LASER VISUAL SYSTEM

Senator GOLDWATER. Please explain the advantages and disadvantages of the laser visual system being developed for the Army.

General KENYON. The advantages of the laser visual system include:

—Elimination of scene smearing effects at low altitudes that result from image movement because the laser system has no components that have significant time constraint. This results in a much clearer visual presentation in the cockpit.

—Simplified color registration that is performed in the laser table. This enables the scene to have a more precise color content.

—Elimination of the light bank used to illuminate the standard model board. Eliminating the light bank reduces the power consumption from a typical load of 200 kilowatts to approximately 30 kilowatts. Furthermore, there is a corresponding reduction in air conditioning required to cool the standard camera model board room of approximately 70 percent.

—Scoring accuracy of simulated weapons is improved because of the inherent precision of the laser beam.

—Camera model room maintenance requirements are reduced, and therefore, a corresponding reduction in maintenance cost. Disadvantages of the laser visual system includes:

—Safety requirements for the laser system requires a complete system of door interlocks.

—The entire model board room must be light tight to preclude spurious light signals from entering the projected visual scene.

—The floor supporting the model board and gantry crane must be completely isolated from vibration.

PLATFORM MOTION IN FLIGHT SIMULATOR

Senator GOLDWATER. What is the Army's assessment of the value of platform motion in a flight simulator?

General KENYON. No studies to date have been completed that accurately correlate simulator motion systems to training effectiveness. The majority of research has been in the area of fixed wing simulators training relatively high altitude tasks. The results have generally failed to indicate that platform motion cueing enhances the effectiveness of simulator training; however, they have identified that training effectiveness is improved by motion systems for tasks involving slow flight, takeoff, and landings. The Army's aircraft, however, cannot fight and survive at high altitudes. Instead of flying aircraft at high altitudes with the relatively stable platforms of fixed wing aircraft, the Army flies inherently unstable rotary wing aircraft at or very near ground level, nap-of-the-earth flight. In this type of environment, analysis indicates the ground becomes nearly as great of a threat as the enemy forces. Proprioceptive cues provided by simulator motion systems are critical for alerting pilots to aircraft position. Aircrews depend on this cueing in actual flight, thus, it is reasonable to include platform motion during training in Army simulators.

Senator GOLDWATER. Is the cost of this feature justified?

General KENYON. Based on the Army training mission and the requirement for proprioceptive cues provided by motion systems, the cost of this feature is justified.

Senator GOLDWATER. Which simulators currently under development will incorporate platform motion?

General KENYON. The AH-64 Combat Mission Simulator is the only Army simulator under development and it will have platform motion.

HELMET-MOUNTED SIMULATOR

Senator GOLDWATER. What is the Army's assessment of helmet-mounted simulator display systems?

General KENYON. Concept evaluation of a helmet mounted visual system is scheduled for 1985. At this time, helmet mounted visual systems are a high risk development. There are a number of research projects currently underway by the Air Force and Navy which are being monitored by the Army. The potential benefit of the systems is the ability to eliminate large, expensive "out-the-window" display systems.

Senator GOLDWATER. Are there any current Army plans to procure such a system?

General KENYON. No.

SIMULATOR TECHNOLOGY

Senator GOLDWATER. To what extent has the Army participated in cooperative efforts with the Air Force or Navy to develop simulator technology?

General KENYON. The Army has a long and continuous history of cooperative development of simulator technology with the Navy through an interservice agreement and collocation of the Program Manager for Training Devices with the Navy Training Equipment Center in Orlando, Florida. A significant product of this collocation in addition to purely information exchange is the benefit of a common technical and business base.

The Army participates as a member of the Joint Logistics Commander's Technical Coordinating group on simulators and training devices. Participation of all services is aimed at methods that will not only improve training effectiveness but will also shorten the acquisition cycle and lower acquisition costs.

Army, Air Force, and Navy cooperation in developing advanced computer generated imagery visual systems is a third direct area of interservice cooperation. The Visual System Component Development Program (VSCDP) Program Element 63216A is the Army's product in this effort.

Finally, all services are actively seeking to apply Ada high order language to simulation through formal agreement. It is expected that by working together we might all be able to implement Ada by fiscal year 1987.

SIMULATOR LABORATORY

Senator GOLDWATER. The Air Force has a simulation laboratory at Williams AFB near Mesa, Arizona which as the lead simulation lab for DOD has quite a lot of advanced simulator equipment. Would any of your programs derive a benefit by allowing industry access to this facility as GFE to evaluate systems concepts and simulator requirements of new weapons systems such as the Army's Advanced Rotorcraft Technology Integration (ARTI) program or the LHX Program?

General KENYON. There might be benefits to industry through allowing access to this facility for evaluation of system concepts and simulator requirements. Any benefits accrued, however, would be more in the area of engineering simulation as opposed to training simulation.

The Army plans to use the Rotorcraft Systems Integration Simulator (RSIS), a Joint Army/NASA program, as a method to evaluate systems concepts and requirements for the Light Family Helicopter (LHX) Program. Under current thought, contractors selected for Full Scale Engineering development would provide a dedicated cockpit to allow for full system valuation. Such use, it is believed, will allow for carry-forward of data from engineering to training simulation. This carry-forward is expected to be a major contributor toward the Army goal of fielding a training simulator one year prior to the first unit equipped with the LHX aircraft.

AVIATION SIMULATORS

NAVY

Senator GOLDWATER. What is being done in the (Army, Navy, Air Force) to centralize management and accountability over the development and procurement of simulators?

Admiral DUNLEAVY. The Navy is taking several actions aimed at centralizing simulator management. First, let me note that we strongly believe centralization should not separate, but further integrate, simulator and weapons system management. This is directly in line with Defense system acquisition directives and ODS

guidelines, issued at congressional direction, to strengthen simulator acquisition management and oversight.

In aviation, we have upgraded simulator and training system acquisition management to Air Program Coordinator status, on a par with other major system program managers, and co-located it with the program managers under the Naval Air Systems command senior acquisition executive.

Other initiatives include issuing navy-wide instructions to increase the priority and visibility of simulators in all phases of the acquisition and review process, and assignment of centralized assessment responsibility within the Office of the Chief of Naval Operations. Again, the focus is on improving ties between simulators and weapon system development and procurement. We have also centralized simulator inventory and configuration status accounting systems.

Senator GOLDWATER. Should the first simulator for a major weapon system be planned for delivery before or after the delivery date of the actual weapon system?

Admiral DUNLEAVY. In my judgment, it is imperative that the first complete suite of simulators be delivered prior to the first weapon system deliveries.

Senator GOLDWATER. What is the current practice?

Admiral DUNLEAVY. It is both DoD and Navy policy to have simulators in place and ready for training upon first weapon system delivery. This is a very challenging requirement. In order to achieve essential replication of weapons system characteristics and configuration, simulator development, step-by-step, must be done concurrently with the weapon system development. This combination of critical commonality and timely delivery mandates the greatest possible integration in the development and production efforts and their management.

Senator GOLDWATER. What benefits would you expect to realize from delivering the first simulator ahead of the weapon system?

Admiral DUNLEAVY. The benefits expected from early delivery of simulators derive from the earlier availability of training capability. This results in earlier attainment of operational readiness, improved safety, and reduced training costs. Most modern weapon systems cannot be successfully introduced and meet minimum safety and readiness objectives during initial operation without the availability of effective, properly configured simulators from the outset. When the required simulator capability is lacking, we are forced into unsafe and extremely costly half-measure work-arounds. Let me say that, in my judgment, over emphasis on front end cost avoidance in simulator development and production is certain to be self-defeating. In the end, the increase in total cost, perhaps including lost lives and aircraft, dwarfs the expense of delivering essential, properly configured simulators on time.

AVIATION SIMULATORS

Senator GOLDWATER. How many different Navy flight simulators are currently in production or development? Please provide a breakout of these simulators.

Admiral DUNLEAVY. The following Navy flight simulators are currently under developmental or production contract. Four basic groupings are used to identify these simulators: Part Task Trainer (PTT), Cockpit Procedures Trainer (CPT), Operational Flight Trainer (OFT) and Weapon System Trainer (WST).

Aircraft	Quantity	Trainer type
Simulators in development*:		
AV-8B	1	OFT.
	1	WST.
SH-60B	1	OFT.
	1	PTT (ASW sensor).
T-45	1	PTT (instrument flight).
Simulator in production:		
AV-8B	1	OFT.
	1	WST.
	1	CPT.
A-6E	1	PTT (team tactics).
Ch-53E	1	CPT.
P-3C	2	WST.
	1	PTT (ASW acoustic).
T-34C	9	OFT.

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Aircraft	Quantity	Trainer type
SH–60B	2	WST.
	1	PTT (ASW sensor).
SH–3H	2	PTT (tactical navigation).
F/A–18	4	OFT.
	3	PTT (air-to-air/ground tactics).
	1	PTT (hands on throttle and stick).
EA–6B	1	PTT (team tactics).
E–2C	1	Do.
TH–57B	3	CPT.
TH–57C	6	OFT.
AH–1T	1	WST.

*RDT&E—funded flight simulators produced under development contracts are, in fact, first article deliverables to fleet users.

COST OF AVIATION SIMULATORS

Senator GOLDWATER. Provide the total authorization request in fiscal year 1985 for each of the following: Flight simulators; other related training devices (requiring authorization); modifications for these devices; and R&D by program element and project. Provide the same data for the Five Year Defense Plan.

Admiral DUNLEAVY. The authorization requested for these purposes is:

Purpose	FY ($000 APN)		
	1985	1986	1987–89
Flight simulators	55,775	76,131	771,218
Other training devices	83,466	64,163	240,689
Modifications	231,941	236,831	816,322

Program element	Project	Description	FY ($000 RDT&E,N)		
			1985	1986	1987–89
62757N	WF–57–526	Training devices and simulation	3,510	3,519	11,426
63208N	01142	VTXTS	2,199	8,317	25,025
63733N	W1773	Training devices technology	8,790	9,874	31,270
64214N	W0652	AV–8B	5,800	2,100	
64714N	W1112	SH–60B trainers	3,125		

F/A–18 COMBAT TRAINERS

Senator GOLDWATER. How many F/A–18 combat trainers are to be procured?

Admiral DUNLEAVY. The present plan is to procure three (3) Part Task Trainers (PTTs), eight (8) Operational Flight Trainers (OFTs) and seven (7) Weapons Tactics Trainers (WTTs).

Senator GOLDWATER. How many have been procured to date?

Admiral DUNLEAVY. Two PTTs, five OFTs, and four WTTs have been procured to date.

Senator GOLDWATER. Provide a funding profile and acquisition schedule by fiscal year for the entire program.

Admiral DUNLEAVY. The funding profile, which includes modifications/updates, and acquisition schedule for F/A–18 simulators are as follows:

[In thousands of dollars]

	PTT	OFT	WTT	
Fiscal year:				
1979	1	1	1	49,100
1980	0	0	1	30,448
1981	0	1	2	113,032
1982	1	2	0	42,029
1983	0	1	0	33,612
1984	0	1	0	28,602
1985	1	1	0	63,552
1986	0	1	0	42,241
1987	0	0	2	92,090
1988	0	0	1	57,782
1989	0	0	.....	18,509

Senator GOLDWATER. Will all F/A-18 air combat trainers have air-to-ground visual capability?

Admiral DUNLEAVY. The OFT has a very limited air-to-ground capability. It is planned to incorporate air-to-ground capability in the WTTs commencing in FY 85.

Senator GOLDWATER. What air-to-air visual simulation will be incorporated in the F/A-18 trainers?

Admiral DUNLEAVY. The 2E7 WTT will have simulation capability for two friendly and three threat aircraft, SAMs, air-to-air gunnery, and missiles in one versus one, versus two, and two versus one scenarios.

F-14 WST

Senator GOLDWATER. Describe briefly the threat simulation capability incorporated in the F-14 WST.

Admiral DUNLEAVY. The F-14 WST threat simulation includes five threat aircraft and four threat missiles against which the F-14 can utilize electronic countermeasures as well as gunnery and all missiles in the F-14 inventory.

Senator GOLDWATER. Is this simulation replicated in a generic way or does the simulator contain actual enemy threat data?

Admiral DUNLEAVY. Actual threat data are used in the F-14 WST.

FLIGHT SIMULATOR PROGRAM FOR VTXTS

Senator GOLDWATER. Describe the flight simulator program for VTXTS. Please address the projected number and types of systems, IOC's and planned locations.

Admiral DUNLEAVY. Two types of simulators will be used in VTXTS: an Instrument Flight Trainer (IFT) and an Operational Flight Trainer (OFT). The OFT will be equipment with a wide angle computer generated day/night visual system whch adds the capability of training in formation flying, weapons delivery, air-to-air gunnery, and carrier qualifications taught in the advanced stage of the curriculum.

VTXTS simulators will be sited as follows:

Site	IFT	OFT	IOC
NAS Kingsville, TX	4	8	Jan 90
NAS Meridian, MS	3	7	Sep 92
NAS Chase Field, TX	3	7	May 94

PROGRAM ELEMENT

Senator GOLDWATER. What are the programs related to simulation that are being accomplished in Program Element 63720N? In Program Element 63733N?

Admiral DUNLEAVY. No simulation related efforts are included within Program Element 63720N. Technology base funding for simulation is included in Program Element 63733N. Specific technology tasks addressed are: Training Technology Demonstration and Utilization, Visual Systems Simulation Development, Computer

Technology for Training Systems, Sensor Systems Simulation, Intelligent Training Systems Development and Part-Task Training Alternatives.

Senator GOLDWATER. Please provide a breakout of all the activities being funded under Program Element 63208N (VTXTS). Please provide status, milestones, and projected costs.

Admiral DUNLEAVY. Simulator-related activities under Program Element 63208N include the development of one Instrument Flight Trainer (IFT), without a visual system, which will then be reconfigured as an Operational Flight Trainer (OFT) with the addition of a day/night visual system. The Full Scale Development Phase began on October 2, 1984 with a projected IOC milestone for the initial IFT and OFT of January 1990. Development costs are projected to be $30.3M.

Senator GOLDWATER. Provide a breakout of Program element 64703N Training Devices Prototype Development. Explain which projects are being developed as subsystems and which are being developed as complete future simulators.

Admiral DUNLEAVY. There are no aviation simulator developments under Program Element 64703N. The current task within this program element is the Battle Group Tactical Trainer. This device is a generic, multi-platform surface warfare training system.

CONTRACTOR MAINTAINED SIMULATOR PROGRAMS

Senator GOLDWATER. How many flight simulator programs are currently contractor maintained? Provide a list of these programs. Do these represent cost savings when compared with Navy maintained simulator programs?

Admiral DUNLEAVY. The following Navy flight simulators are contractor maintained:

Weapon system and simulator type

T-34C—CPT, OFT.
T-44A—OFT.
TH-1L—OFT.
*E-2C—CPT, OFT, PTT.
*F-14A—OFT, WST.
*A-6E—WST, PTT.
*P-3A/B—WST, PTT.
*TA-4J—OFT.
*T-2C—OFT.
*EA-6A—WST.
*EA-6B—PTT, WST.
*SH-3—CPT, OFT, WST.
*F/A-18—PTT, OFT, WST.
*SH-60B—PTT, OFT.
*S-3A—OFT, WST.

SIMULATOR MAINTAINABILITY

Senator GOLDWATER. What improvements in reliability, maintainability and availability are achieved in flight simulators built to military specifications rather than to commercial specifications? Are the additional costs associated with military specifications justified?

Admiral DUNLEAVY. The Navy maximizes the use of best commercial practice. The use of Military Specifications (MIL-SPECs) is, however, very cost effective in certain areas. A typical flight simulator utilizes commercial off-the-shelf equipment, Government Furnished Equipment (GFE) and trainer-unique software and equipment. MIL-SPECs included in simulator contracts are aimed almost exclusively at the portion of the trainer hardware/software designed and built by the trainer contractor for use only in that trainer. These specifications require the contractor to use sound engineering design practices detailed in the standards. If the contractor is truly employing sound practices in his everyday effort, then the requirement to follow these specifications should have little impact. However, experience has shown that many do not follow their own published internal design practices, and thus, the requirement to follow the MIL-SPEC forces accountability on the design.

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*The formal Contractor Operation and Maintenance of Simulators Program (COMS) was initiated during FY 83 and includes the systems marked with asterisks. It successfully replaced organic Navy simulator maintenance on these systems. Currently, competitive firm fixed price contracts are being utilized. Cost studies show COMS is resulting in a 55 percent cost savings.

The majority of the impact of the use of MIL-SPECs in the trainer acquisition process lies in three areas. The first is in the area of software development; the second is in the delivery of documentation, and the third is in the use of standard parts. All of these areas represent a higher initial investment, but result in life cycle cost savings.

Requiring software development to be accomplished in the disciplined manner defined by the MIL-SPECs is consistent with DoD wide initiatives and has been demonstrated to be the most effective way to ensure that the software will meet performance, budget, and schedule requirements.

The data delivered in compliance with the imposed MIL-SPECs permit the government to maintain the trainer with government personnel or through a competitive maintenance contract; make changes in delivered software either with government personnel or under a competitive contract; and verify that the trainer meets contractual requirements.

The requirement to use approved DoD standard parts in the design and manufacture of the trainer-unique hardware has two benefits: the standard parts have a demonstrated reliability that far exceeds their commercial equivalent; and replacement/spare parts can be purchased competitively from a number of qualified vendors.

Therefore, while the use of MIL-SPECs may increase the initial investment cost, there is a significant payback over the life of the simulator in reduced operating, maintenance and update costs.

AVIATION SIMULATORS

Senator GOLDWATER. Please provide the actual availability and utilization rates of your operational flight simulators, and compare them with the availability rates that were designed into these simulators. This data should be provided on a monthly average basis for the past 3 years.

Admiral DUNLEAVY. The below listed simulators were designed for 3400 hours utilization per year, based on a 16 hour day, 5 day week, 50 week year less projected non-availability due to crew turn around time and mission scenario loading. The average percent availability shown below accounts for lost time due to non-scheduled maintenance, modifications and other factors which preclude utilization; it reflects the capability of the trainer to fully perform all aspects of the scheduled training mission. Some simulators show a utilization rate in excess of planned objectives due to an increased training load (e.g. third shift, weekends) and, where feasible, utilization of the trainer in partially mission capable mode. The preliminary fiscal year 1984 data on trainers maintained under the Contractor Operation and Maintenance of Simulator (COMS) program, initiated in fiscal year 1983, shows an availability rate of 95% or greater and an increase in utilization. As more trainers come under COMS, it is anticipated that there will be a corresponding improvement to overall simulator availability and thus utilization.

Aircraft W/S	Device	Fiscal year 1981–83 average	
		Availability rate percent	Utilization rate percent
A6E	WST (2F114)	55	114
EA6B	WST (2F119)	60	130
A7E	WST (2F111)	64	76
A7E	OFT (2F84B)	76	101
A7E	TACTICS (2F84B)	94	74
AV8A	OFT (2F99)	84	63
E2C	OFT (2F110)	64	83
E2C	TACTICS (15F8)	45	90
E2C	TACTICS (15F8A)	65	66
F-14/F-4S	(ACMS (2E6)	33	107
F-14A	WST (2F112)	52	90
F-14A	OFT (2F95)	79	75
F-14A	FTT (15C9A)	73	85
F18	OFT (2F132)	82	142
F4S	WST (2F88)	79	67

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Aircraft W/S	Device	Fiscal year 1981–83 average	
		Availability rate percent	Utilization rate percent
SH3H	OFT (2F64C)	83	73
SH3H	TACTICS (2F64C)	87	92
P3C	OFT (2F69E)	82	32(1)
P3C	TACTICS (2F69E)	60	114
P3C	OFT (2F87)	79	89
P3C	TACTICS (2F87)	54	100
P3C	OFT (2F87A)	65	82
P3C	TACTICS (2F87B)	68	82
S3A	OFT (2F92A)	62	70
S3A	TACTICS (2F92A)	47	93
S3A	TACTICS (14B50)	57	79

Note 1: 2F69E OFT utilized to support Naval Reserve P–3 squadrons.

SIMULATOR VISUAL SYSTEMS

Senator GOLDWATER. How will translucency be utilized in simulator visual systems?

Admiral DUNLEAVY. Translucency is being introduced, on a limited scale, into the CH–53 and AV–8B Operational Flight Trainers, and the AV–8B Weapon Tactics Trainer. It is being used primarily as a way of blending information into the visual scene. More extensive capability associated with increased scene content is being developed through IR&D.

Senator GOLDWATER. If translucence capability has been utilized, what has been the payoff in terms of training transfer?

Admiral DUNLEAVY. Translucency in computer image generation (CIG) allows for more realistic simulation of smoke, clouds, and shadows as well as blending in additional scene content. This adds interpositional movement details which can be important in close approach maneuvering done by helicopters and in low level navigation.

Senator GOLDWATER. Is the training transfer anticipated from the added capability of translucency worth the cost?

Admiral DUNLEAVY. Translucency is a means for providing some of the important visual scene characteristics needed for low level flight training. This capability is inherent in several of the more costly, state of the art CIG visual systems and costs associated with an integral translucence capability on these systems is considered negligible.

PLATFORM MOTION IN FLIGHT SIMULATORS

Senator GOLDWATER. What is the Navy's assessment of the value of platform motion in a flight simulator?

Admiral DUNLEAVY. State-of-the-art visual systems coupled with other cueing devices (i.e., G-suit, G-seat, buffet) have virtually eliminated the requirement for platform motion cueing in most fixed wing tactical aircraft simulation. Platform motion cueing is still applicable to systems simulating helicopter and VSTOL aircraft.

Senator GOLDWATER. What is the approximate cost of providing a simulator with this feature?

Admiral DUNLEAVY. The initial acquisition of a motion platform is in the range of $400K. This does not include the cost associated with the facility which must house it or the high cost of maintaining it.

Senator GOLDWATER. Which simulators currently under development will incorporate platform motion?

Admiral DUNLEAVY. The Navy is including motion platforms in helicopter systems. These are:

Aircraft and training device

AH–IT—WST.
SH–60B—OFT.
TH–57C—OFT.

HELMET-MOUNTED SIMULATOR DISPLAY SYSTEMS

Senator GOLDWATER. What is the Navy's assessment of helmet-mounted simulator display systems? Are there any current Navy plans to procure such a system?

Admiral DUNLEAVY. Helmet-mounted simulator display systems have been demonstrated to be a technically feasible means to provide the wide angle, high resolution displays required for aircrew training. However, practical application for this technology still leaves a lot to be desired, especially for tactical aircrew.

The Navy has no current plans to provide a production version of a helmet-mounted simulator visual display system. The Navy is, however, developing an eye-tracking, helmet-mounted system as a part of the technology base R&D program. Following delivery in FY 85, the systems will be used as a test bed to evaluate the cost/training effectiveness of eye-tracking visual display systems.

SIMULATOR TECHNOLOGY

Senator GOLDWATER. The Defense Science Board conducted a study recently to determine how effective our simulator technology efforts have been in the past and to determine where our future efforts should take us. Please provide for the record a summary of this report as it applies to Navy flight simulators.

Admiral DUNLEAVY. The Board's findings as they relate to flight simulators are: need to incorporate RDT&E improvements into training devices more rapidly; impact of military specifications upon trainer acquisition; reserve component requirements for trainers; use of computer assisted instruction; requirements identification, acquisition and full support funding of training devices and training; concurrent trainer and weapon system procurement; and need for OSD level oversight of training device development.

The Defense Science Board stated that innovations in training devices and methods "pay off handsomely" and that improvements in training technology can improve our level of training. The Navy recognizes the potential cost-effectiveness payoff of emergent technology in training, both classroom instruction and system simulation. In addition to our own research, we are in constant close touch with the other Services and with industry in our efforts to identify useful new technology-derived methods and capabilities. Intrinsically desirable proposals and innovations are honestly evaluated for prospective benefit in competition with gains estimated for other investments. Demonstrable cost-effectiveness will continue to pull new technology into our training methods and equipment.

The board commented that the current acquisition process is time consuming and inefficient from a cost standpoint due to the impact of military specifications. I have addressed the Navy's position on the use of military specifications earlier in my testimony.

The Board commented that it is essential to provide adequate training assets to support Reserve Component requirements. Within fiscal constraints, the Navy fully supports procurement, modification, and maintenance of training devices and training program for the Naval Reserve.

The Navy is in compliance with the board's recommendation for more computer-based training systems. The Navy has introduced computer-based training into the fleet in support of the F/A-18 and the AV-8B. Additional examples are the Computer Assisted Mission Planning System (CAMPS), the F/A-18 and planned T-45 computer assisted instruction systems. In the near future ASW acoustic analysis and radar imagery analysis will also be supported by deployable microcomputer-based training systems.

The Navy fully concurs with the Board's recommendations concerning earlier starts in training requirements identification, planning, and acquisition; full funding for approved training programs; and concurrent acquisition and delivery of dedicated simulators and their parent weapon systems. We have, for years, supported all of these objectives. Given the complexity of the system involved, and their interrelationships, it is a challenging undertaking.

During the debrief, Admiral Kidd stated that, historically, training programs and trainer support are usually the first things to go when budgets get scrubbed. This may have been true at one time. However, the Navy now emphasizes a policy of holding the weapon system program manager directly accountable for the timely introduction and success of the entire integrated system, including training and logistics packages. It has been repeatedly demonstrated that funding, development, and management outside the weapon system envelope result in failure to meet delivery

schedules and training requirements. This, in turn, results in serious degradation in aircrew readiness and safety.

Senator GOLDWATER. To what extent has the Navy participated in cooperative efforts with the Air Force to develop simulator technology?

Admiral DUNLEAVY. The Navy and Air Force have a long history of cooperative efforts and technical exchange. These efforts are coordinated through a framework of liaison offices at the Naval Training Equipment Center, the Air Force Aeronautical Systems Division, and Air Force Human Resources Laboratory. This working relationship is set forth in formal letters of agreement. Additionally, informal technical communications among the engineers and scientists occur on a daily basis.

Some current cooperative efforts are: eye-tracking displays providing enhanced resolution in the visual area of interest which offer the opportunity to dramatically improve display performance for certain applications. Both the Air Force Eye-slaved Integration and Tracking (EDIT) project and the Navy helmet mounted display project have shared both technical expertise and equipment to achieve research goals. As these systems near the demonstration phase, the Visual System subgroup of the Joint Logistics Commanders' Joint Technical Coordinating Group on Simulators and Training Devices (JTCG-STD) is developing evaluation plans to permit comparison and exploitation of these systems.

The JTCG-STD is developing plans for joint service efforts to implement new computing technologies such as Ada and VHISC into the computational systems supporting training devices.

A joint effort by the Naval Air Systems Command and the Air Force Human Resources Laboratory will develop a photographic data base simulator visual system in an effort to increase the visual scene realism while avoiding the escalating costs of computer generated imagery.

Senator GOLDWATER. Thank you for coming. It has been very, very interesting, and very illuminating, and I look forward to tomorrow, when we have the manufacturers here. Tomorrow at 9 a.m. we will hear from Singer, GE, and HRL in the same room, and you are all invited.

Thank you. The subcommittee will be adjourned.

[Whereupon, at 11:20 a.m., the subcommittee was adjourned, to reconvene at 9 a.m. the following day, Thursday, September 27, 1984.]

DEVELOPMENT AND USE OF TRAINING SIMULATORS

THURSDAY, SEPTEMBER 27, 1984

U.S. SENATE,
SUBCOMMITTEE ON TACTICAL WARFARE,
COMMITTEE ON ARMED SERVICES,
Washington, DC.

The subcommittee met, pursuant to notice, at 8:59 a.m., in room SR-253, Russell Senate Office Building, Senator Barry Goldwater (chairman) presiding.

Member present: Senator Barry Goldwater.

Also present: Former Senator Howard W. Cannon from the State of Nevada.

Staff present: Carl M. Smith, James C. Smith III, and John J. Hamre, professional staff members; Inga B. Schoonover, staff assistant.

Also present: Gerald J. Smith, assistant to Senator Goldwater, and Bernard R. Toon, assistant to Senator Quayle.

OPENING STATEMENT BY SENATOR BARRY GOLDWATER, CHAIRMAN

Senator GOLDWATER. The committee will come to order.

As I had to do yesterday morning, I apologize for the lack of attendance, but right above us now is a meeting of all the Republicans trying to figure out how we are going to get through the rest of the session. I am sure the Democrats are having a similar meeting.

If we could just have you fellows figure out a simulator to replace the Senate and the House, I think you would be doing the country a great service.

This morning the subcommittee meets for the second of two hearings on the subject of Department of Defense simulators and simulation technology.

Yesterday we heard from representatives from the Office of the Secretary of Defense and each of the services who discussed the major DOD simulator programs in both development and procurement.

Today we are pleased to hear from representatives from the simulator industry and from the leading military laboratory on simulator development, the Human Resources Laboratory at Williams Air Force Base.

I don't say what I am going to say because it happens to be in my back yard, but I don't think either the services or industry are

using this facility to the extent that they could. It has been developed really to help you fellows and to help the military.

The fact that it is there I don't think you should ignore. I think you should pay more attention to it and if your companies are not regularly visiting it to get ideas from the men who deal with this subject, I think you should start now.

I have asked our guests today to concentrate their presentations on simulator technology, particularly new technologies which are being developed for possible application in future simulators.

The advances that have been made in the past 10 years in simulator technology have been truly remarkable—if similar improvements are possible over the next 10 years—and I think they are—then we will have to be very careful to ensure that our approach to developing and fielding this technology is one that will ensure we derive the maximum benefits for our investment.

I want to impress on those here this morning that it is not the Department of Defense's sole responsibility to think up ideas for simulators. It didn't start with defense, it started with industry. I would hope that we could continue with the simulator companies projecting new ideas to the users, whether they be military or civilian.

You people are in this business on a continuing basis where in the military we have the usual situation where we have very brilliant people attached to a subject for 2, 3, or 4 years and then they go back to some other outfit.

So, if we are going to continue to have real improvements in simulation, I think it is going to have to come not just from a combination of the military and the civilian, but more from civilian initiative.

It has become a gigantic business, as you know. I don't see any reason why we should not continue to encourage new ideas in this field.

We are grateful to have with us this morning representatives from two of the leading simulator developers and manufacturers in the Nation: Singer Co. and General Electric Co.

Representing Singer is Mr. William D. Turner, president, Link Flight Simulation Division.

Representing General Electric is Mr. C. (Skip) Christ, program general manager of simulation systems, General Electric, Daytona Beach, FL.

In addition to these gentlemen, we are pleased to welcome Brig. Gen. Robert R. Rankine, Jr., U.S. Air Force, Special Assistant, Strategic Defense Initiatives, Research and Development and Col. Dan Eliason, U.S. Air Force, Chief, Human Resources Laboratory, Air Force Systems Command, Williams Air Force Base.

Gentlemen, it is a great pleasure to welcome you this morning, we very much look forward to your presentation.

I think, Mr. Turner, you are to lead off. I know that you might have prepared texts. If you do and you desire to put them in the record, they will be put there. If you wish just to go ahead and rattle it off, go ahead.

STATEMENT OF WILLIAM D. TURNER, PRESIDENT, LINK FLIGHT SIMULATION DIVISION, SINGER CO.

[Slide presentation.]

Mr. TURNER. Senator Goldwater, ladies and gentlemen, first of all, I would like to express our appreciation for the opportunity to testify before the committee as a representative of the Link Flight Simulator Division, but more importantly as a member of the training simulation industry.

This industry has matured in recent years to truly become a part of the military industrial complex. We feel that as an industry, we have the capability and credibility to propose and deliver training systems that will be a great benefit to the services as they are employed.

I should like to touch on two basic subjects. Thinking of technology, where we think we are today and where we are going in the future, I would like to cover a little bit of history, but leading into exactly what the technology is that we are dealing with now and in the future, and then close out with what I see as the role of the simulation industry as part of the DOD-industry team finally then winding up with some conclusions.

Simulators have evolved—many in the room are still at the right age to enjoy happy hours in the so-called blue box. We have certainly come a long way since then.

Looking at the period of the sixties, which really marked the major step forward in simulation, you might call this the advent of the digital era which brought us out of the blue box syndrome and put us in the world of simulation training.

In this period of time the prime element or the prime direction of simulator development was to teach specific skills. In particular, thinking of aircraft, we centered upon ownerships, as we call it, in the cockpit where we are talking about flying qualities, powerplant operation, accessories, tactical systems, and so forth.

The technology that supported this was first analog and in the late sixties was converted to digital. At first special purpose digital computers were employed because the people who produced general purpose digital computers could not make them cost effective enough.

So, we moved quickly ahead in the full application of digital, still using analog computations to handle some of the other aspects of training such as radar which is an area we will touch on as we go through the presentation. In the visual area in this era we are dealing with 60-foot model boards, cameras, moving gantries and whirling dervishes to try to project to the pilot the out-of-the-window scene.

Still we broke the ice and with this technology we were able to achieve some significant advances. The aircrews or the pilots were able to master the transition into new flight machines and the operation of increasingly complex aircraft in a safe, cost-effective environment.

As we all recall, the basic justification for simulators in this era was cost avoidance; reducing flying hours, reduced fuel consumption, and so forth. This is what we were trading off in the sixties and early seventies.

Typical of this equipment is the T2C for the Navy which is a basic trainer and is still in operation. Another example is the F–4 series. Believe it or not, over 70 F–4's were delivered in this era and are still in operation throughout the world. Finally, as was mentioned yesterday, the first element of the Army's synthetic flight training system. The UH–1 is a complex with four cockpits, each with 88 total cockpits being delivered. All of these systems are still operating.

One of the things that the simulation industry has not been able to do; we can't simulate the Senate as suggested. We also can't simulate rust. The devices keep chugging on and are performing very, very well. This UH–1 complex for example, operates at 98 percent availability around the clock at Fort Rucker and other Army locations.

In summary, the sixties and early seventies were focused on individual skills, taking advantage of the technology as it existed. The emergence of digital computations was again focused in the cockpit, and systems oriented around the pilot.

We really had a major breakout in the last few years, with what I call entering into the era of crew skills training. Here again technology is the mother of invention and has allowed the industry to move very aggressively in this area.

Primarily what has happened is that we have been able to move outside of the cockpit, into the external environment. This is the difference between glorified cockpit procedure training or basic operational flight training where we simulate only what is in the cockpit, and our beginning to look outside in terms of the airborne sensors as they operate with the external environment and interact with the pilot in the loop. Being able to present the entire situation very importantly hinges on the advent of visual simulation technology.

We talked about digital being the driver in the sixties and early seventies. The driver in terms of our technology today is in the visual system world. We are now in the visual simulation era.

When you think of today's battlefield and tactical environment, this Vugraph is purposely very busy because that is what the environment is here. If we look outside the cockpit, we find many things as far as simulating the enemy as well as simulating the friendlys so to speak. Everything that is going on in the cockpit, radar simulation, electronic warfare, ECM, the entire spectrum of our simulation is impacted by the external environment.

Here again the use of digital computation has made this all possible. Not only the advent of digital, but very, very high speed digital. With the advent of todays minicomputer series plus special purpose processors we were able to provide information to the crew in real time. Real time simulation is the crux of simulation technology today. A lot of other people in the digital computer world are not concerned about being able to compute, display, and react to pilot input as in the real world.

Moving into the other areas of visual simulation, we are also able to simulate the radar world as a digital data base. We are not only in the out the window visual simulation area, but we are also simulating the sensors that are associated with visionics systems. I will discuss this in more detail later.

Again, the thrust, the leading edge of todays technology, is visual simulation. I am sure my compatriots from General Electric will be presenting to you a presentation on digital image generation. You will be able to see exactly where technology sits.

This visual scene however, represents going back in history, to one of the first digitally generated scenes. It was created by a system delivered very early in the F-11 program and subsequently on the Black Hawk.

As you can see, it is like something that a first grader might put together, but at the time was a very, very tough technical program, giving an electronic artist approximately 1,200 to 2,000 lines or edges to work with. He had to create the best scene possible to try to generate the cues that pilots need for takeoff and landing. Technology was limited by computer speed fast enough to be able to create this scene in real world time and present it on various displays.

This next generation scene is a typical data base that is emerging out of the Army Apache combat mission simulator program. You can see the major steps forward in terms of picture fidelity and realism. Here is a specific data base showing a confined landing area in a typical German town with another Apache helicopter shown. Here we are talking approximately 6,000 to 8,000 edges to describe this kind of scene, again presented in real world time.

You will see later, I am sure, from the dynamic presentations what is right around the corner. We are now talking about things like texture, photo map techniques where you can take photographic data and convert to digital format and use it in scenes like this and also shadowing effects.

The real key in digital visual technology is the advent or move into higher and higher speed digital circuitry. VLSI circuits combined with various special purpose processors are being used to be able to manipulate and work the kinds of data here to present this king of scene.

Again, a typical scene showing aircraft, with parts of the aircraft articulating such as folding wings. We are actually able to see pilots in the cockpits doing things, such as arm motions to signal break out of formation, and so forth.

Actually in the visual world the generation of the image such as this pretty picture is really only the tip of the iceberg relative to the broader technology that is associated with visual.

Actually in terms of the technical problem we must think of not only the of basic image but must take that image and apply it to the tactical situation such as the Apache helicopter where you not only the basic image but must take that image and apply it to world, but you are also looking at the world in terms of its infrared representation or low light level television.

You are working the images through the visionics system onboard that simulated aircraft to present to the pilot and gunner what he is capable of viewing in bad weather or nighttime. So, just to be able to generate the picture is only the very beginning. The next part is to take that data base and work with it to be able to manipulate it through the entire tactical system.

Part of this manipulation is coordinating it with the radar returns which are really a form of visual presentation so that as you

are flying and you are looking at low level terrain avoidance radar or ground mapping radar, the pilot could relate what is viewed with the IR scene and out-of-the-window views.

A great deal of research and development effort, both by contractors and the Government is needed to adapt this digital technology into the military simulation environment.

The picture shown here is describing IR returns on a full night scene. Interesting point: In a typical out-of-the window daylight scene you can get away showing a tree in two dimensions as a piece of texture. When you get into the IR regime actually that tree has to take on a three dimensional aspect because if you approach it from the shady side and are looking at an obstruction, that shows an entirely different visual signature. It tells the pilot to do something entirely different from what he would do if he were approaching it from the light or sunny side. There are many such nuances that have to be considered to have good training. Also, the signatures of friendly or enemy aircraft such as the Russian Hind must be created.

Typical of this era, we show here the F–14 weapon systems trainer of the Navy. As described yesterday, this system has now been placed in a full visual dome to project to the air crew the actual tactical environment. They are able to simulate firing the Phoenix missile system, to engage enemy aircraft as well as train in the tactical environment of electronic warfare and countermeasures.

You also heard mentioned yesterday the B–52 shown here. This is really the first full weapon system simulation with total crew involvement such as the six members of the B–52.

Seven systems have been delivered and are in operation throughout the country. The complex includes an offensive station, a defensive station and a pilots station with capability to train through the whole mission spectrum, including in-flight refueling as well as low level navigation around the world.

Another crew training application, and this is still under development, is the Apache, one of the most complex avionic or visionic systems that we are aware of. Here the U.S. Army has taken another step relative to looking at the expanded use of visual systems. We heard mentioned yesterday the need to be able to automatically generate visual data bases, to be able to have the true tactical environment.

With the Apache CMS will be delivered what is called VISGEM, which is an automated technique of taking Defense Mapping Agency data and converting it into visual data as well as using it as the basic format for IR simulation and, of course, radar so that you can correlate and coordinate all of the visionics input.

Senator GOLDWATER. Pardon me. In this simulator you include the gunner and the pilot and they can work together?

Mr. TURNER. You have the pilot and the copilot gunner. Both can operate independently on the date base or as a coordinated team, firing the whole complement of weapons including the Hellfire as well as rockets, and so forth. The data base that contains enemy vehicles of various types, ground as well as air, so that you do have a capability of target identification and destruction.

Very, very key to the capability, and I want to stress this because it really sets the stage for where I think we can go in the

future as far as application of simulation, is the movement toward compilation of a very detailed and useful data base. Technology is building the capability to generate these data bases automatically while also being able to deliver a capability to the user for off line interactive manipulation of the data base so he can bring on line various new tactical scenarios.

Senator GOLDWATER. Is this complete simulator installed in any one place now?

I flew part of it at Yuma. I wonder if you have the whole thing at any one place?

Mr. TURNER. The AH-64, Senator, is under development. It is due for delivery or fielding in 1985. You can see it and touch it and fly it right now. But it is not complete. I imagine what you saw is one of the part task trainers built by Hughes in support of the flight test program. That was not part of the combat mission simulator program.

Senator GOLDWATER. It was the IR simulation for gunnery.

Mr. TURNER. I see. That is another program which is, in effect, off line.

Senator GOLDWATER. General, while they are fixing the gadget, Senator Cannon reminded me of the days when he used to fly in a dome. I remember we had one at Williams and one at Luke.

Do you still operate that way, go up and simulate combat in the dome?

General RANKINE. We have two dome interactive combat trainers still operating at Luke. That was designed originally as a research tool. It transitioned from research to operational training where it is now full-time operational training and 10 percent research.

Senator GOLDWATER. I think he and I flew out of Douglas.

General RANKINE. That facility is operated by the Tactical Air Command as an operational air trainer. It is being upgraded. General Creech directed 2 years ago that we upgrade that.

We are in the process now of having the contractor change the F-4 cockpit to an F-16 cockpit. It will be up to date and continue to be used.

Senator GOLDWATER. Do the troops up at the Red Flag come down and use it?

General RANKINE. No, sir. The training load is not specifically directed to that. We have had some experience with our facility over at Williams which is more air-to-ground configured and uses a different concept.

Instead of a reflect dome, it uses mosaic with TV screens surrounding the cockpit. That facility has been moved in Red Flag training.

Mr. TURNER. We will pick up in real time once again. This, again, is a picture of the B-52 weapon system trainer in operation. It allows full crew interactive, mission training supported by a digital data base providing real world imagery through many thousands of miles. It is possible to fly, as was mentioned yesterday, strategic missions that you couldn't fly in any other way.

In jumping ahead, if you look at the technology of the simulator relative to full crew training, it allows you to project combat readiness.

I think the new era that has really emerged here with this technology is the ability to take full crews and put them in a situation where you can get out a quantified product that you can evaluate, you can test, you can look at and say we indeed have a combat-ready crew.

This generalized chart is really constructed from data that was generated by Williams Air Force Base and HRL. It is very significant relative to the use of simulators to generate a combat readiness profile. In relation to the Red Flag exercises, it is my understanding that in relation to actual combat experience, the ability of an air crew ramps up quite rapidly which determines their survivability which in turn can be measured by a certain number of missions. Once they reach that point and survivability has been achieved, their ability to carry out future missions is at its peak.

In reading the data that was developed by HRL, through simulation of some of the Red Flag exercises, we found that through simulation we were moving the air crews well up on the survivability and performance curve before getting in the aircraft.

We think of that in terms of our wartime potential, heaven forbid, the fact that the air crews and other crews have to go into battle as efficient as possible when the first shots are fired that through crew simulation you see the capability of maintaining a much higher combat readiness or combat efficiency than we ever could before.

In summary, we are today able to look at total crew skill. We are moving in the Visual Era, but in particular we are evolving in an area where we are generating data bases that have some very, very interesting applications in the future of simulation as they are applied to training.

We see the future really centering about what is called Team Skills. In this area we think of today's battlefield situation of combined arms where you are talking about attack helicopters working with scouts, working with Tac Air combined with the volatile change of enemy situations.

You can really picture inserting into this environment through simulation the actual air crews operating together and in concert with the command and control of the battlefield in real time simulation and decision processes.

The thing that really makes this possible, Senator, is the evolution of data base technology that is able to be the format or the baseline for the application of full tactical simulation. Thinking again of the data bases created in the visual world, the Scout helicopter can see what he should see relative to the control of the attack helicopter and actually see the land battle developing.

The user certainly in the future is going to be able to interact with the data base on a real time basis, modify the tactical environment, even thinking ahead of artificial intelligence application, being able to act and react to certain tactical situations; putting them into the simulation and in real time being able to measure and monitor combat readiness.

Thus we have evolved from a rudimentary start in the sixties. We are entering the mideighties and as far as we can see, the application of simulation is actually getting more exciting every day.

You can see it evolving into other areas besides aviation, but aviation certainly has been leading the way.

I think the world is going to be our oyster, as you indicated, for the next 10 years in the application of what we have here as applied to the Defense Department requirement.

I would like to talk in closing briefly about the various roles of the players as we see them in this evolving industry. They all play a very important and major part.

The simulator first has to start as a training system with the user generating the requirements. We in industry have to interface with the user. In so doing we actually use many of the facilities that the Government has, such as the Human Resources Lab which, by the way, is very effectively used by a number of industrial forces.

Interface with the prime weapon system developers is also mandatory because the availability of systems data forms the basis of the training system design.

In the acquisition process I think the Department of Defense has stepped up very, very aggressively and we have seen evolve particularly over the last 5 years, where the Army, Navy, and Air Force each have a very effective acquisition capability. The ability to accumulate the requirements, put them in terms of specifications and procurement packages, let competitive contracts, monitor them and field the equipment very effectively is in place. These organizations are also the focal point for the necessary supporting research and development. Much of it is carried out under Government sponsorship, but a lot of it done independently by the industrial base that is working this problem.

We in the simulation industry also, I think, bring a very specific skill to this marketplace. It is somewhat controversial, on occasion, relative to what role do we in the simulator training business play relative to the prime contractors. There are schools of thought that the prime contractors can do the whole thing with the simulator training people taking a secondary role.

I just want to point out a few things here where I think we as an industrial force should be recognized as just that. We can provide a unique service. Even going back to the original concept of the training simulator where we talked about so-called ownship simulation, are things like motion system and the instructional system which are unique technologies.

In modern simulators if you look at the complexity of the total system only about 20 percent really represents the technology associated with the prime developed ownship. We in the industry and the Government have spent the money necessary to develop an expertise in the rest of the technology building blocks to go forward, in putting together a total training system or, roughly 80 percent of the development task.

If you look at the areas of expertise which are evolving in the future it tracks one on one as well. The simulator industry really functions in these primary development areas not as a sideline. So, we really think we have a major contribution to make to the continuation of this technology and its use as a recognized industrial force.

Furthermore, the contractor base has been actively participating with the three DOD agencies and there are a number of initiatives that have been undergoing and ongoing to do things which I am sure are of great interest to you such as keeping the equipment cost effective while maintaining the expansion of technology.

There are a number of initiatives underway right now to commercialize the procurement process of this kind of equipment. The equipment works in a benign atmosphere, it is computer oriented. It does not have to meet airborne capability requirements. There are a number of additional initiatives to think of how we do things commercially to cut down the cost and time.

Another very interesting point which was touched on yesterday is the use of total training packages and the commercialization of these packages. The KC-10 total training system was mentioned before. That has changed the type of supplier providing the service. American Airlines is now running that program.

The recent C-5 competition, the competition is between United Airlines, American Airlines and Flight Safety. It puts a whole new cast of characters in the scene. The concept is to permit the pilot to qualify by going through the so-called schoolhouse, bringing him out at the other end a qualified pilot in whatever new vehicle is required. If he does not match up, he goes back and recycles at the expense of the contractor and not the Government. A very, very interesting concept.

Also there is a significant move to contractor logistics support, which is not only the bodies to be used to maintain equipment, but also the handling of spare parts and the depoting of equipment to support the simulators.

Another major step forward, and the services are working very, very diligently on this, is to be able to field simulators concurrently with the fielding of the first operational aircraft. We have historically been very bad in terms of being able to do this. It has been a mutual problem. We have mutually stepped up to it and for the first time we are now seeing major combat mission simulators and weapon systems trainers coming along to support the actual aircraft systems as they are fielded.

Last, but not least, the application of technology. We are moving ahead together in such areas as the application of new higher order languages such as ADA.

In conclusion, Senator Goldwater, I would like to make the point that we feel in our industrial base we have the capability of offering to you training simulators that make a unique and essential contribution toward achieving what we all want and that is peace through preparedness.

Thank you very much.

Senator GOLDWATER. Thank you.

I would just like to make one comment. You were talking about your team as your next problem. I think that is very, very important. With the recent decision of the Air Force and the Army to begin combining their efforts, I think it is a recognition by the Pentagon that any future wars are not going to be fought by one service.

We will have land wars fought by the Air Force and the Army and island wars fought by the Navy and Air Force. Your idea there

in the team presentation where you can simulate the total strategic approach of an enemy and the strategic reaction and the development of tactics by the defense, I hope you can push that.

One of the great weaknesses we have in this committee is the ability of individuals to visualize. Talking about things like the Bradley battlewagon, many members will say, "Why do we need that?"

When we talk about the M-1 tank, "Why is that so important?"

What I am thinking about is the presentation by simulation of the complete battlefield, whether it is Europe, whether it is the Middle East, whether it is the South Pacific, or wherever it might be, so that not just a team as we think of the services, but a team as we think of civilians like ourselves who can better understand what the subject is.

Are you making that type of approach?

Mr. TURNER. Yes, we are.

Senator GOLDWATER. I can visualize one of these crazy kid games where you sit down and you can call on the reserve unit back there for reaction or you can call on a tank commander out here or ground support aircraft commander. I hope you will push that. I would like to be kept up on what you are doing and I would like to be kept up on what the services are thinking on this and also all other simulators.

I am even attempting, and I have had pretty good reaction so far, to bring the different war colleges in before this committee and to allow any Member of the Senate to come in and get educated on what we talking about. Then I think we will get away from this trend toward parochialism, "They make the tank in my State so I have to get some more of them," or "They make the AH-64 in Goldwater's State."

We have to start thinking about what is good for the whole team and that is what it is going to be. So, more power to you.

Thank you very much.

Mr. TURNER. Thank you, Mr. Chairman.

Senator GOLDWATER. Now I think we have next General Electric's presentation.

By the way, this is—I called him Mr. Cannon, but he could be General or Senator. He was my boss here for a long, long time.

STATEMENT OF C.C. (SKIP) CHRIST, PROGRAM GENERAL MANAGER OF SIMULATION SYSTEMS, GENERAL ELECTRIC CO.

Mr. CHRIST. My name is "Skip" Christ. I am general manager of the simulation systems program in Daytona Beach, FL, with General Electric.

I welcome this opportunity to appear before you as a representative of the simulation industry. In my presentation this morning I will be emphasizing computer generated imagery [CGI] visual systems.

I will discuss the results of several Government-funded research and development programs, the status of two existing programs and some of the future applications of simulation.

I will also show you a video tape which will help illustrate some of the advances in computer-generated imagery technology.

General Electric's Corporate Laboratories initiated development of computer generated visual systems back in 1958. After nearly 10 years of development, the technology was transferred to Daytona Beach and research for product applications for flight simulators was started.

As most of you know, and as Mr. Turner showed you this morning, the first flight simulators were cockpit instrument trainers. Later, cockpit visual systems that portrayed the out-the-window environments were added by photographing large terrain boards with servo-driven TV cameras displaying the photo image.

The terrain board approach, however, is restricted by limited dynamic capabilities and limited gaming areas. It also requires a large facility and is expensive to operate and maintain.

By the late 1960's technology advances in computer hardware and software made it possible to seriously consider using the computer to generate the visual environment and make it completely interactive with the trainees' actions.

Through the efforts of this committee, the services, and industry, computer-generated imagery has now progressed to a point that offers great payoff potential to the training readiness of this country.

In our modern computer-generated visual systems we can now provide data bases representative of actual battle zones and offer threat avoidance and weapons proficiency training. This total capability to accurately simulate the combat environment will save lives by having pilots better prepared for the initial actual combat mission.

Experiences in Vietnam have shown that a disproportionate number of aircraft losses occurred within a pilot's first few combat missions. This was attributed to a lack of experience in detecting and avoiding surface-to-air missiles and other threats. I believe the data Mr. Turner showed earlier from HRL, substantiates this point.

Simulators with today's computer visual systems will allow inexperienced combat pilots to actually see what a SAM looks like as it approaches his plane and evaluate the effectiveness of his evasive maneuver without becoming a missing-in-action statistic on one of his first combat missions.

The successful development of this technology has not been easy nor inexpensive. Both the Government and industry have invested millions of dollars during the past decade and we are now at the point of payoff. I would like to draw to your attention three R&D programs which illustrate the success of your past funding efforts.

First is the advanced visual technology system, program element 63227F, at the Human Resources Laboratory at Williams Air Force Base in Arizona. This project, which has been strongly supported by this committee over the past several years, has provided much of the basic technology development required for fighter aircraft visual systems.

Another significant project is a joint Army-Air Force project called the visual system component development program, program element 63216A which has served as the demonstration test bed for a revolutionary breakthrough in visual systems technology called cell texturing.

With this new development we are able to combine photographs with computer generated imagery to create realistic visual scenes. As you will see in the video tape, this allows us to achieve a degree of realism heretofor not achievable.

This success now makes simulation of helicopter missions and nap-of-the-earth flying practical and extremely effective. This project derives its primary mission funding from the Army and will be installed and tested by the Air Force at the Human Resources Laboratory in Arizona.

Finally, I would like to mention the Navy's visual training research simulator, program element 63733N, at the Naval Training Equipment Center at Orlando, FL. Senator Goldwater, you may recall dedicating this system in 1978. This simulator has made significant contributions to the special problems of aircraft carrier training and the use of computer visual systems with dome displays. In addition, helicopter training requirements as they apply to Navy and Marine use, have been evaluated to determine desirable characteristics for new simulators.

Each of these research programs, as well as others, has made, and is making a significant contribution to the technology developments necessary to develop better simulators.

Now, I would like to show you a video tape which quickly covers the span of visual technology developments. You will see scenes, all generated by computer, as they appear on the display to the trainee or user. The tape will start with some of our earliest work and follow the application of the technology over several years in different simulators.

At the end you will see clips from two full mission capability systems that employ the cell texturing technology.

May we see the tape, please.

[Video tape presentation.]

Mr. CHRIST. General Electric pioneered development of computer generated imagery, or CGI, technology back in the fifties and sixties. The first full CGI system was used by NASA to develop mission and procedures for the Apollo Moon landing program.

Here in the late sixties and early seventies we developed CGI for use in training pilots. Systems were built for both the military and for commercial airlines. These early systems provide highly cost-effective training, but realism in the scene content was limited.

In the late seventies great improvements were made in scene realism. Higher scene content was feasible due to the rapidly decreasing cost of integrated circuits and other components which make up an image generating system.

Also, new techniques were developed to add realism. The major breakthrough was the development of texturing which substantially increased realism and provided better motion cues. While texture generation provides improved scene realism, even more realism is required for applications such as nap-of-the-earth flights.

To meet this challenge, General Electric has developed a breakthrough in CGI technology which advances scene realism in a new area. This new technique provides scenes so real it is hard to tell you are not looking at a real world scene. To demonstrate realism and effectiveness of the new technique, we will follow a simulated mission.

You are listening to the pilot and gunner of an Apache helicopter gun ship code named Muller 20. They are on their way to support scout helicopter Rover 16. You will see mutations between Rover and A-10 aircraft code named Gunrunner. These scenes show the capability of the cell texturing technique to display convincing weather effects.

After flying out of the bad weather area Muller 20 joins up with Rover 16 who has spotted enemy armor.

Firing rockets at the enemy armor shown here as they would appear in the gunner's sights, Apache will respond to attack on the A-10 from the farm house.

Note the realism of the weapons effects now possible with cell texturing.

After repositioning to another battle area Rover 16 will take fire from a Soviet Hind which will then be hit by fire from the Apache.

The cell texturing for the first time, the detail needed for nap-of-the-earth flight in realistic mission scenarios is now available.

Now we will fly a fighter mission. On this flight we will engage in both air-to-air and air-to-ground weapons delivery.

The remarkable realism provided by the new generation computer systems permits General Electric to remain the world leader in CGI technology.

Senator, I hope that you will agree that the technology advancements that we have demonstrated in this tape today are worthy of the funding you have provided all three services on the R&D programs.

Now, I would like to take a moment to talk about some of the programs that we have fielded.

Senator GOLDWATER. Before you do, was all this simulation computer developed?

Mr. CHRIST. Yes, sir. Everything you have seen there was generated by computer in our laboratory system at Daytona Beach.

Senator GOLDWATER. The scenery and everything?

Mr. CHRIST. The technology you see here, the cell texturing technology, is what we are developing for this visual system component development program which is the joint Army-Air Force program.

The first place this technology will show up is out at Human Resources Laboratory in Arizona where in that program the technology is being developed for the Army, but used in the Air Force's existing simulator vehicle demonstrator.

Next summer the hardware will be incorporated into the system at Williams and you will be able to see it for the first time there.

Shortly after that it will be available at McDonnell Aircraft Co. in St. Louis where we accepted a firm fixed price contract in January of this year.

Senator GOLDWATER. Thank you.

Mr. CHRIST. Now I would like to take a moment to go into some of the existing programs we have fielded. A key program I would like to talk about is the USAF C-130 weapon system trainer.

On the USAF C-130 simulator, General Electric provided the visual system and Singer-Link provided the motion based cockpit. Our visual on the C-130 is considered the most advanced visual system in use for training anywhere today.

In addition to normal training, the USAF is using the C–130 weapon system trainer to train cockpit crews in such risky maneuvers as low altitude parachute drops and high-gravity maneuvering to avoid enemy threat detection.

The visual system at Little Rock contains a model of real-world terrain which provides over 60,000 square miles of training area. A Red Flag data base, containing aircraft scenarios to fit C–130 combat training, is introducing C–130 crews to real-world Red Flag terrain.

Military Airlift Command personnel at Red Flag have frequently noted the higher skill levels of C–130 crews trained with this visual system.

New C–130 visual data bases can be generated which will allow crews to pre-fly actual combat missions. For example, we are working with the U.S. Air Force at Little Rock to model the Island of Grenada. This will provide C–130 crews with the realism of flying actual Grenada missions in a variety of different weather and combat conditions.

The C–130 weapon system trainer is being used 18 hours a day, 5 to 7 days per week and our visual has been providing more than 99 percent availability.

Next I would like to discuss the U.S. Army's Conduct of Fire Trainer [COFT] Program which is the largest contract ever awarded in simulation history. Over 230 systems will be fielded to provide training to tank commanders and gunners on the M–1 and M–60 main battlefield tanks and the M–2 and M–3 fighting vehicles.

The COFT is housed in three transportable shelters and consists of a realistic replica of the crew compartment, and instructor station, electronics which generate the computer imagery and a debriefing/maintenance area.

The COFT provides full color computer generated landscapes and includes moving ground and airborne targets.

It also provides malfunction simulation and has a computerized scoring system which provides immediate feedback to the crews on their performance.

The COFT program, which was awarded in 1982, is both ahead of schedule and under cost. The first production units will begin deliveries later this year. The crews that have been trained so far in our prototype system at Daytona Beach have been very pleased with the COFT's operational training transfer capabilities and feel the trainers will have a positive impact on their performance in the actual vehicle.

In addition to providing hardware, General Electric is also responsible for developing training scenarios and providing full contractor maintenance. This approach is in keeping with the growing trend in the U.S. military to procure services instead of pure hardware.

I might add on the point you raised of combined arms training and team training, General Kenyon touched on it yesterday. The Army is planning to take the COFT systems you see here and combine training COFT on the same data base and let the crews train as a platoon.

Downstream they are looking to combine the AH-64 and other helicopter simulators on the same data base to achieve force on force training.

As Mr. Turner pointed out, both the services and industry are working on that concept.

With the COFT program as an experience base, General Electric has recently embarked on a new venture which goes beyond the role of developing training curriculum and maintaining equipment in the field. This venture will provide training services utilizing General Electric-owned and operated facilities and staffed and professional General Electric instructors.

Our initial application of this concept is for the training of international F-5 pilots.

In January 1986, we will be opening the Center of Advanced Airmanship near Phoenix, AZ. The center is designed to complement existing F-5 aircraft training programs—those conducted in-country as well as those conducted by the U.S. Air Force as part of our security assistance programs.

The Center will include an F-5 weapon system simulator and classrooms equipped with state-of-the-art computer-based instructional systems. The Center will be staffed by professional instructor pilots, all with solid credentials, who will offer a comprehensive academic curriculum which will be tied together by a syllabus covering conversion, air-to-air, and air-to-ground training.

The student will receive classroom instruction on weapon systems, radar principles and procedures, conversion procedures, mission planning and air and ground attack principles.

The simulator will offer the student the opportunity to become proficient in emergency procedures, weapons delivery and threat avoidance as well as normal flight and all-weather operations of the aircraft.

The students who continue their training at Williams Air Force Base will also benefit from the local area orientation our visual system provides. This approach makes simulation training affordable and eliminates the problems with maintenance which have been experienced in the international market.

Although we are addressing only the needs of the international market today, we feel that this approach will be beneficial to the U.S. services as well in the future.

In summary as a result of the R&D programs which I described earlier, the computer visual technology is here today to meet the services' training needs.

We recognize that these visual systems must not only provide the kind of scene realism that you saw today, but they must also be affordable. To address the issue of affordability, General Electric has invested millions of dollars to develop state-of-the-art microelectronics for use in our visual systems.

As a result of both the Government's R&D and General Electric's investment, we have been successful in reducing the size of the computer generated imagery electronics by a factor of three while achieving significant performance improvements.

Evidence that computer visual technology is both here and affordable is seen by looking at recent procurements by the aircraft manufacturers. In January of this year, as I mentioned earlier,

McDonnell Aircraft Co. in St. Louis ordered three of our new Comput-Scene IV visual systems for use in their research facility at St. Louis.

Hughes Helicopter has recently ordered a system for use on their simulator facility near Mesa, AZ, which will be used for development work on the LHX program.

As you know, many of the simulators currently in use today for aircraft such as the A-10, F-15, F-16 and AH-64 were procured without visual systems since the technology at the time of procurement could not satisfy the full mission training requirements.

Today's realistic cell texture technology can now meet the stringent training needs of attack, fighter and helicopter pilots.

Upgrade of the existing simulators by the addition of today's visual systems will substantially increase their training effectiveness. Today's visual systems will also meet the training needs of new vehicles such as the U.S. Navy's landing craft air cushion vehicle.

Our military forces have waited a long time in order to get visual systems that can meet their training requirements. I am pleased to report that industry can now meet their needs.

This completes my report. Thank you, Mr. Chairman, for the opportunity to address this subcommittee today.

Senator GOLDWATER. Thank you very much. It is very interesting.

Now we will turn to General Rankine.

It is a pleasure to have you with us this morning.

STATEMENT OF BRIG. GEN. ROBERT R. RANKINE, JR., SPECIAL ASSISTANT, STRATEGIC DEFENSE INITIATIVE, DCS, RESEARCH, DEVELOPMENT, AND ACQUISITION, AIR FORCE

General RANKINE. Thank you, Mr. Chairman.

The Air Force thanks you for giving us a second opportunity to address this committee on the matter of simulators. Today we will address technology.

One of my duties as General Russ' special assistant is to be the advocate for the science and technology programs of the Air Force in Air Force Headquarters. This is a new assignment, something that the Air Force has not done for a number of years, but it does show, I think, Air Force increased emphasis on the technology for the future.

Yesterday General Williams presented a briefing on Air Force use of simulators and he gave several examples of simulators in use, in production, and in development.

Today we will address the technology program which will lead to the future Air Force simulation capabilities.

As you are well aware, Mr. Chairman, Human Resources Laboratory has a division at Williams Air Force Base which specifically addresses the technology of simulators.

I have with me today Col. Dan Eliason from Williams who will present a briefing to you and the committee on Air Force simulation technology programs.

STATEMENT OF COL. DAN ELIASON, CHIEF, HUMAN RESOURCES LABORATORY, AIR FORCE SYSTEMS COMMAND

Colonel ELIASON. Senator Goldwater, we appreciate your interest in this very vital field of emerging technology. It will be our pleasure to discuss with you today the Air Force's role in its pursuit of advanced technology.

FLYING TRAINING R&D—METHODS AND EQUIPMENT

My division of Air Force Human Resources Laboratory chartered under Air Force Systems Command through Aerospace Medical Division is responsible for the pursuit of improved technology. That includes not only the equipment which you first described today, but also the methods for utilization of that equipment.

To that end, I have about an equal mix of behavioral research people and engineering research people at the facility at Williams.

It has been suggested that with increasing systems complexity, we have an increase in need for complex trainers. Of course, the increasing complexity is just about always correlated with increasing cost.

Assumption: Complex weapon systems require complex trainers which means high cost?
Real Question: How much complexity is needed to accomplish effective training?

The question that to us is in the research field: How much complexity is required to accomplish the mission, or stated another way, can we build a cost-effective trainer to meet the need of today's training in tactical warfare?

RED FLAG PRETRAINING IN SIMULATOR HAS INCREASED PILOT SURVIVABILITY

We have some initial indications from our Red Flag studies that training in a simulator of the past decade's vintage visual systems, with very limited straight edges and no cell textured trees, still produced a 15- to 20-percent increase in survivability for those pilots who went to Red Flag following the simulator training over those who went to Red Flag without the simulator training.

Then the question becomes: Do we need to go further? That brings up two questions: Should we hold performance steady and let today's increase in computer capability drive that cost down for a given performance or should we follow today's increased computer advances, as you have seen on the video tapes, and take that increased performance and increased cost or both?

That indeed is the question that we hope to respond to.

SIMULATOR R&D ROADMAP

Five year R&D plan developed.
Centers on training effectiveness issues: Component cost effectiveness; total system cost effectiveness.
Defines simulator training value versus system complexity.

To that end, our division has recently put together a 5-year technology roadmap on simulator systems. We have briefed it and had it approved in the last 2 months by the commander of Systems Command.

Because the high cost driver is visual simulation, we concentrate on that area. We are looking at not only the component cost, that is of the visual portion of the simulator, but also at the cost effectiveness of the total system.

Can we build a device which may or may not have a very extensive visual system that will do the training job if it is appropriately blended in with the aircraft range, et cetera?

What we are attempting to do is define the simulator terrain complexity value versus its cost.

WHERE ARE WE TODAY?

Tanker transport bomber mission: Simulator hardware meets needs; syllabus requires refinement.

Tactical fighter mission: Visual system inadequate; full mission training strategies undefined.

In regard to where we are today in the simulator world to meet the Air Force needs, it is our belief that the tanker transport bomber mission category can adequately be met by today's technology.

The simulator hardware is there that will do the job, as evidenced by the C-130 and the retrofit of the C-141, and C-5 simulators.

The KC-135 is the same and the B-52 system, which Mr. Turner from Link mentioned, is adequate, we feel, to do the job in terms of hardware development.

That does not mean that the research has entirely ended because we do see a need to continue to ask questions about how we best implement that technology once it is brought to fruition.

For the tactical fighter mission, the fighter/attack/reconnaissance [FAR] role, we feel that the visual system still needs to be improved. While we can indeed produce a good picture, the question remains: Can we produce it in a cost-effective manner so that we can afford to attach it to all the simulators we have in the field?

Because we don't have a full visual capability operational yet, we don't know all the answers about how one would employ that or what kind of strategies are required to be employed in the training system.

Senator GOLDWATER. Before you move on, relative to a tanker simulation, have you noticed an increase in the ability of the student pilot to hook up as opposed to the old way, where you send an IP with him and after many attempts, he could do it?

Does training in a simulator improve his ability to learn quickly the actual hookup?

Colonel ELIASON. Yes, sir; the Air Force does have some preliminary interim air refueling part task trainers which do show a benefit to the degree in fact that the Simulator Program Office now has under procurement another air refueling part task trainer for SAC. They will be using that regularly.

SAC also uses refueling capability in their weapons system trainer, the B-52. In fact, that is a general finding of research that simulation always gives us a little jump. The guy who has been through the simulator can catch on a little bit faster than the guy who goes straight into the airplane once he goes to the airplane.

Over time it levels out because if you practice enough in an airplane, you will get good sooner or later, but the simulator gets us a little edge for the first sortie.

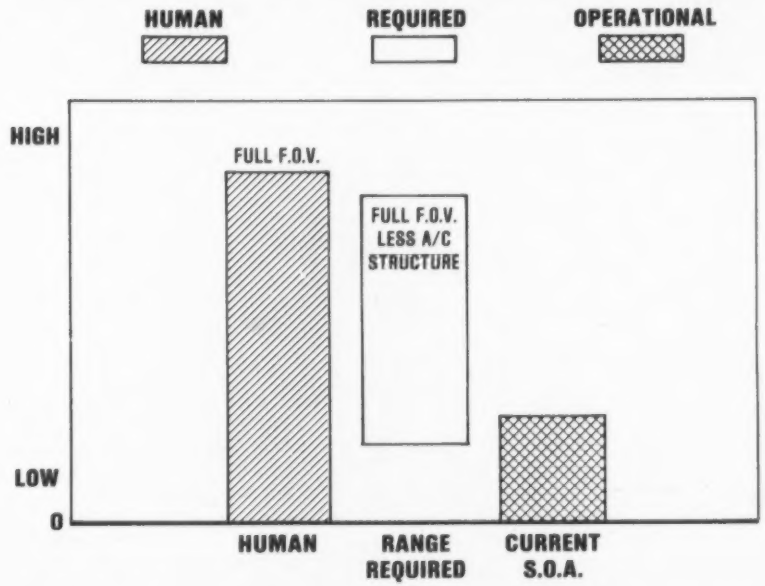
Senator GOLDWATER. Have those learning today been exposed to that tanker simulation?

Colonel ELIASON. No, sir; not until he is in operational training.

The T-37, T-38 sees only formation training and that in the airplane only, not in a simulator.

The big cost drivers, as I mentioned, are in the visual area and three of those specific factors I would like to discuss now, that being field of view, resolution and scene content.

FIELD OF VIEW



Field of view, of course, is the amount of coverage you have. I am showing here from low to high in blue the field of view of the human operator. Basically our vision is unrestricted. We can turn our head and look everywhere but under the sole of our feet.

So, we have a complete full field of view. That is represented by the middle bar which has some restriction due to cockpit structure.

We have deliberately in the Tactical Air Command gone to airplanes that have essentially bubble canopies so that that amount of coverage that is restricted is minimized.

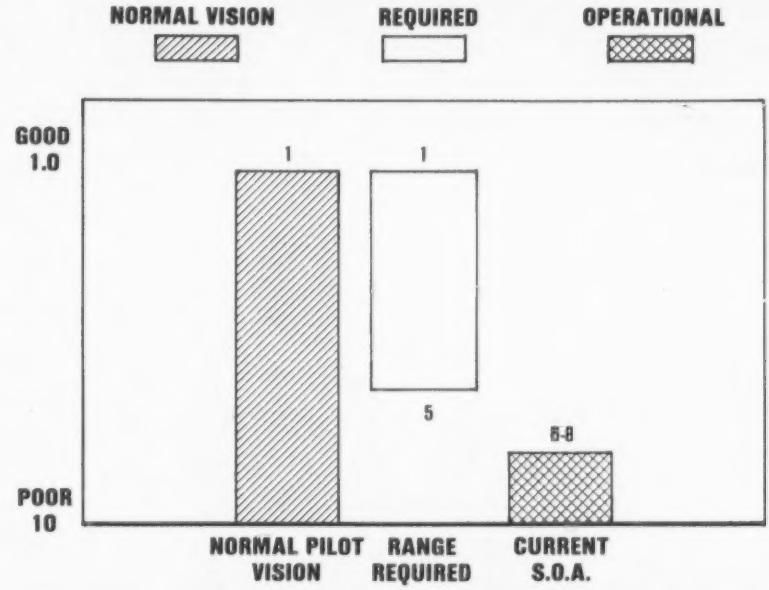
So, that is the field of view that we feel needs to be trained. As you alluded to yesterday, we didn't want to train the pilot to be fixed in his vision because that is not the way he operates. We want him to have full visual coverage so that if there is somebody back there, he can check that in the simulator because that is the skill he needs to have in combat.

We want to train him for that. Our present day systems typically have one to three channels of visual capability fixed in space

around the cookpit; while that is suitable for the F-111, for the helicopter community, and for the tanker transport bomber mission. It is not suitable for a bubble canopy fighter.

So, we have a considerable role to accomplish here in terms of getting technology to provide us with the full field coverage for a fighter mission.

RESOLUTION



Resolution is what determines how clearly an object is displayed in the usual scene. Once again, it is represented on the blue bar with a value of one arc minute being good. We think that that full amount is probably required for the tactical mission.

Until we go to a completely enclosed cockpit, which I don't see in the near future, we are going to have a requirement for trainers to be able to produce nearly the full capability of the human eye, a very demanding task for the technology to come up with.

Our current systems are on the order of 20-180, 20-200, somewhere in there, which is between visually handicapped and legally blind. So, we have a long way to go in bringing that resolution up.

I will show you in a moment two technology options we have to achieve that capability.

Now, let me mention that resolution is related to field of view. In fact, expanding the field of view is like walking into the Monday night football screen at the stag bar. If I get up close, the picture is fuzzy, I lose resolution because I spread that energy over a wider field of view. If I sit at home across the room from my 19-inch TV screen, that resolution is very good, a nice sharp, clear picture, because I compress that energy.

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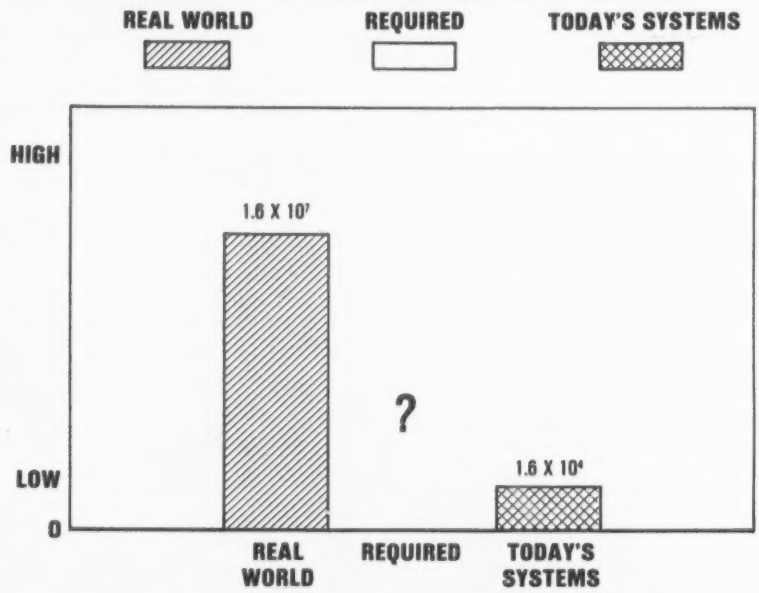
That is what we have to do in the simulator world, to compress those small bits of information into a small area to get the high resolution, but, of course, that collapses our field of view. We can't afford to put 19-inch TV screens around the cockpit to keep that resolution up.

So, we have had to go another route and I will detail that when I get to the hardware.

SCENE CONTENT



The third cost driver is scene content. Even if we had full field of view and high resolution, what would we put in, how much stuff is out there?

We really don't know the answer to that yet. Current technology is capable of giving us, as shown by the green bar, about 16,000 edges for points where the lines of the computer screen creating the image cross. That was the old way of generating the straight lines.

We had the engineer count the number of straight line crossings the computer could achieve. That was normally 16,000 edges. My people calculated the real world for any given field of view that the human might see might contain as much as 16 million edge crossings or equivalent which means we are on the order of magnitude of about 1,000 or so off from where we should be.

The reason we have no bar in the center designating what is required is because we don't know how to measure information content within the field of view, but we are working on that. I suspect in 6 to 9 months we will have derived a figure of merit that will be acceptable to the engineering community and understandable to the fighter pilot.

To that end I have one of my best behavioral scientists working with a very bright young chap at Tucson Air National Guard in charge of the A-7 flight program and, consequently, very keenly interested in the visual process, both in the airplane and in the simulator.

Weekly I lock those two fellows together in a closet and say give me a measure of scene content and they say, "Right, we will get to that."

They are closer every day. I think we will have it soon.

Basically we know that we have to get increased scene content. As we can see from the video tape, the evolution of straight faces with simplistic lines to very complex cell textured trees there is a significant difference in that information content and we are going to set out to measure that, define it, calculate the value of it and then determine the cost effectiveness of buying the machinery to achieve it.

TACTICAL FIGHTER VISUAL SYSTEM DEVELOPMENT

PE 63227F. ADVANCED SIMULATOR TECHNOLOGY

Objective: Enhanced aircrew training through development of hardware/software systems.

Two approaches to display high resolution, wide FOV visual information: Full field of view done; helmet mounted display.

Approach to achieve scene content: Joint AF/Army effort; computer image generation system currently under acceptance testing. However: Growth potential limited and costly.

To measure our success in meeting objectives; Perform parametric evaluations; study transfer of training.

To pursue this visual technology improvement, we have an advanced development program for simulator technologies to address both the hardware and software issues. Three drivers, of course, are the field of view, resolution and scene content.

I will come back to these two ways of achieving that, the dome and the helmet mounted display, in a moment.

I will move on now to mention that the scene content pursuits are currently underway, the bulk of the funding being Air Force and Army for the system which you saw General Electric present.

The first six channels of that system have been delivered and just this week started acceptance testing out at Williams Air Force Base. We will receive the remainder of the channels this spring and we will undergo rigorous evaluation of the system for both its hardware characteristics and its value in training.

We may have pressed that particular kind of technology to its fullest extent. We want to continue to look at an improvement so that if it is necessary, we can carry it forward.

We have a 62-hardware development program underway at the present time to look at alternate technology using actual photographs of cells for the entire scene. That is being jointly funded by AFSC and the Navy.

The two ways we are going to evaluate these new systems, as I indicated, are both parametric, which is a fancy word for saying we put a machine in there and measure the number of dots and we put a man in there to see what he can see and write it down.

More importantly, we look at transfer of training, put the guy in a simulator, let him use it in a training session and put him out in the airplane and see if his training in that system is different than the chap who didn't have it.

To achieve that higher resolution, at the same time preserve that needed wide field of view, we are developing dome systems which take two projectors inside a large dome as opposed to the systems we have nowadays where the cockpit is surrounded by multiple wide TV screens having low resolutions. We are going to put the projectors inside the dome with the pilot.

It will require at least two projectors, one to give him a wide field of view background about equivalent to his normal coverage of the two eyes. Out in the periphery we don't need very much resolution because the human eye can't detect much out there.

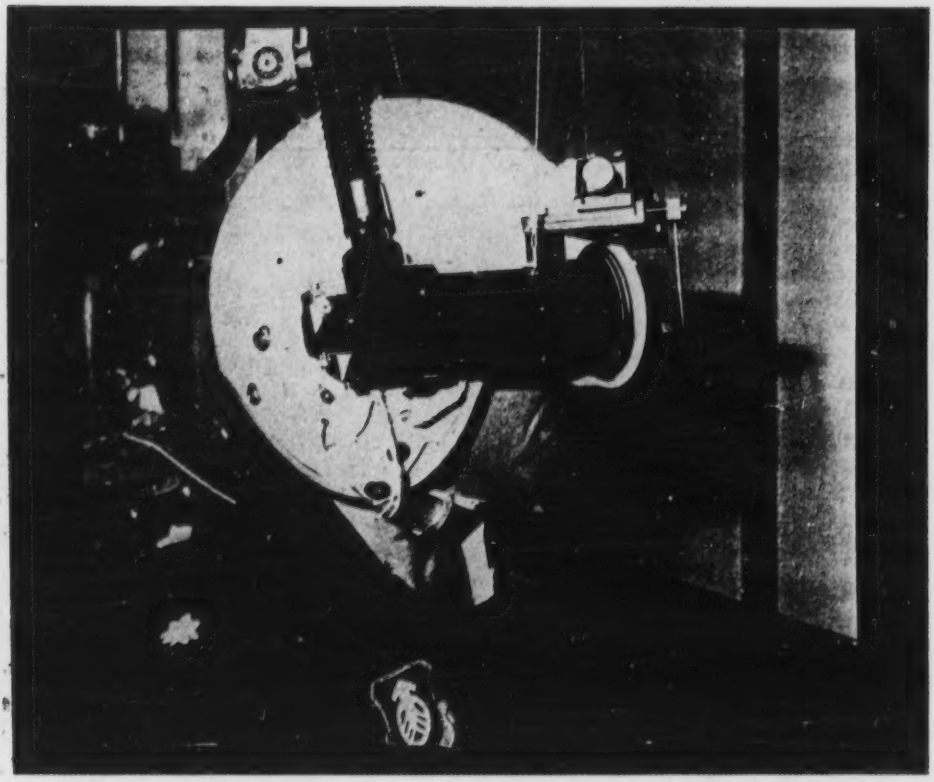
It is awfully good for detecting motion, but not very good at detecting details. So, we can get by with lower resolution in the far distant areas of the visual field, but we need high resolution in the center.

So, we take a second projector and squeeze that energy down to that narrow diameter required to give us this higher resolution. We control the back projector with head motion and measure his head motion.

We have to give him a new device to track his eyeballs so that his eyeline of sight will be with the projector which is presenting a narrow field of view visual capability.

That dome is under construction as part of the Army-funded visual component system improvement program and the dome actually looks a little better than this. It is fully complete waiting for the cameras to be put in by General Electric.

The second major technology change that we are attempting is this helmet-mounted device mentioned yesterday. By putting the viewing surface closer to the eye, we have less of a problem in creating the necessary energy to make a sufficiently high resolution and high brightness.



This is our first model of the device jointly funded by the United States and Canada on a 50–50 cost-sharing basis. It takes the image which is projected on a rather conventional television kind of projector, pipes it up through a fiber optic bundle to a set of optics on the helmet which shines the picture in front of the pilot's two eyes.

It looks cumbersome, but it is movable. The pilot has to have not only an instantaneous view of the field about him through normal vision, but he has to be able to move that device around with him.

The first version was cumbersome. The big problem was fitting the helmet tight enough, but that was easily solved.

The second generation system, which is much clearer, much higher performance, and much smaller bulk will be delivered in fiscal year 1985.

Both of those will be under evaluation cut at the facility at Williams Air Force Base.

Senator, when you are home, you might want to come and look at that.

Senator GOLDWATER. I would like to see it. I don't believe a fighter pilot is ever going to wear one.

What are you going to do about turning around, keeping your head moving?

Colonel ELIASON. As I mentioned, this is bulky. It is not unrestricted movement, but it does have full range of movement. It is

just that the mask is so big that the head turns before the helmet turns. You can't keep alignment very well in fast motion.

The next version will be light enough so that you can make the rapid transit.

I, too, having been in the fighter business, recognize that difficulty and that is why we are not carrying this as the only technology. This offers a significant improvement in performance.

If you let the engineers build it, they will say, "let us have one of those because it is 10 times brighter than the helmet existing displays."

As long as we have some fighter pilots like yourself and my chaps out there who keep asking that question, we will say, let us make sure that we have both things satisfied, higher performance and the mobility that is required.

So, the second one will be the real test. Can we drive down that form factor to the point where it is real enough?

Senator GOLDWATER. I am coming over to see that.

Colonel ELIASON. We will let you know. I expect it will be in the first or second quarter of 1985.

Senator GOLDWATER. Suppose the pilot wears glasses?

Colonel ELIASON. Not a problem. The glasses do fit underneath.

If we were able, and I think we will be certainly in the future, to provide the necessary visual specifications at an affordable price, we would like to get the whole training at unit level.

We have not given up on that as a goal, but the realities of economics and technology may dictate that we just can't have one of those at every fighter wing. We may not be able to afford that.

So, we are constrained to consider also a center concept. If the training is valuable enough by capitalizing on this new technology and we can't afford it at every wing, is it reasonable for us to fly just a few of them and suffer the TDY cost?

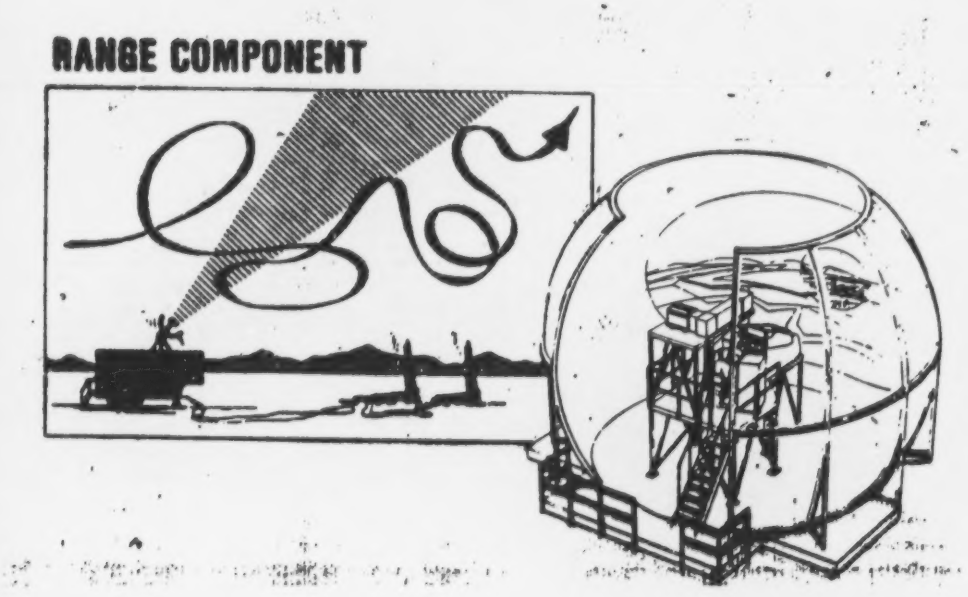
That is one of the questions we need to investigate. We need to look at what Mr. Turner alluded to, the larger scope of training rather than just one simulator component.

OPERATIONAL APPLICATION OF ADVANCED TECHNOLOGY

Cost/performance driven options: Unit level training; training center concept.
Investigate related training effectiveness issues: Instructor operator station; performance measurement; and instructional strategies.

In order to look at that issue, there are some other areas from within our R&D roadmap that have to be brought to fruition, that of the instructor-operator station improvement, some performance measurement measures and look at strategy.

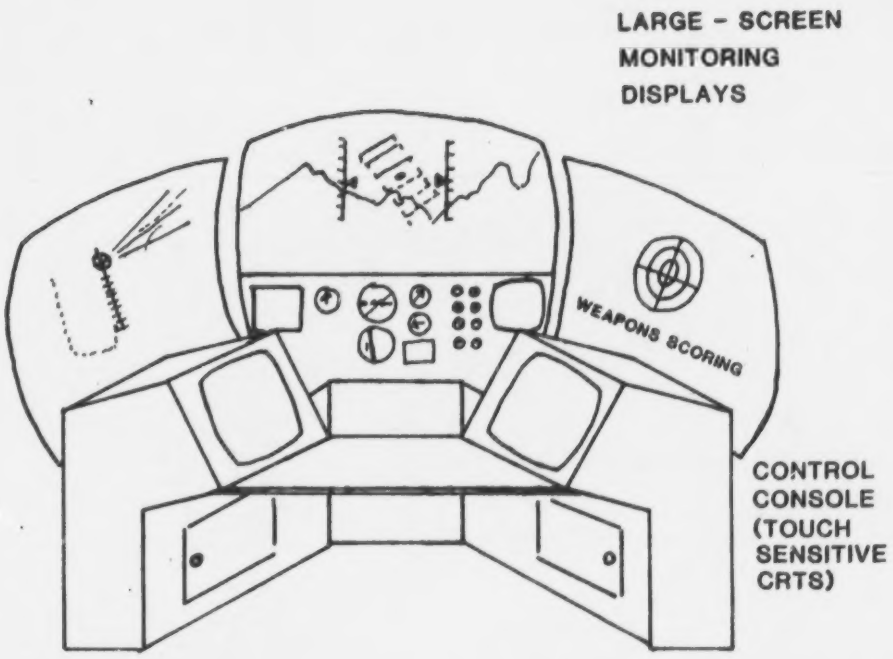
SUPER-SCHOOLHOUSE "CENTER"



The center concept would look at the use of the simulator and arrangement of components. It would be the logical extension of the current Navy Fallon range and Air Force Red Flag range complexes.

Because we have shown some benefits for imagery as precursor for range training, perhaps they should be united and we have proposals to investigate that.

To make the imagery most efficient, we must have a usable and cost affordable instructor-operator console.



You may recognize this as the console from our experimental device at Williams. Obviously a bit too large and cumbersome for use in the field. The instructor pilot can hardly stay current with all these knobs and dials.

We are working on the next generator of instructor-operator console to make it simpler and easier to use from a computer interactive standpoint.

There are some other refinements that we think are very necessary to make this simulator more valuable. The big thing we want to do is make it usable as a briefing-debriefing aid, a play-back capability within the instructor-operator station so that the pilot can actually see the results of his action, how effective was his use of electronic countermeasure pod, chaff, evasive maneuvers and terrain masking so that he can actually see a missile fly out in full perspective following each of his encounters with a missile, for example.

We have to find a way to accurately measure that transfer of performance from simulator to aircraft.

It is very difficult, of course, to do combat-style training in a simulator and then find some real combat in the airplane where we can check the value of the simulator.

So, we have a three-pronged program over the next few years to try to define the performance measures that will tell us if that simulator training is valuable and if indeed it translates to training in the aircraft.

Lastly, we must continue to develop a better understanding of simulator strategies, how we include that development in the total training package.

C–130 OPERATIONAL TEST AND EVALUATION

During the C–130 weapon system trainer test and evaluation we found that this device with its unique and highly capable visual attachment was more powerful if used in a different fashion than the existing simulators.

The simulator without the visual system was valuable for certain tasks, but with the visual attachment it was more valuable for other tasks. When it was used as just another simulator, it didn't show that much increased performance.

Through our research of the human resources laboratory people on site at Little Rock working with their syllabus experts and training personnel, we defined areas where the simulator with its new unique capability could better be employed and we find that we have much greater training benefit from that device, now that we have changed the strategy, given that we have new technology.

That is an area we will continue to work as we make technical advances.

In conclusion, let me restate that our roadmap for technology is pursuing the three high-cost drivers in the visual field, the field of view, resolution and scene content. We have developed this roadmap and are making those pursuits of that visual area in concert with industry capabilities and potential.

Our challenge, of course, is to demonstrate that technology, bring it to an affordable state and improve the options that might be possible to use.

Human resources laboratory will continue to work in concert with our industry counterparts as well as the Navy and the Army to increase operational readiness and to improve training capability.

That concludes my briefing, sir.

Do you have any questions.

Senator GOLDWATER. We will have questions.

Thank you very much, Colonel.

Colonel ELIASON. Thank you, sir.

Senator GOLDWATER. I will ask you, Colonel Eliason, what is the value in current dollars of the simulation equipment, hard and soft, at your lab at Williams.

Colonel ELIASON. We have researched that and can give you the exact number.

Approximately $110 million in fixed facility equipment replacement cost not counting the new advanced visual technology system which is approximately $30 million plus development cost shared by the Air Force and the Army.

Senator GOLDWATER. This equipment is interoperable with the simulators at Luke.

Colonel ELIASON. Sir, we are not currently running this way, but is is possible. We did have a demonstration where we connected the two domes at Luke with the two domes at Williams and it did run.

We did not find a need for that, although it is possible to do it that way and we have future plans for interconnecting some of our cockpits within Williams. Now we know we can transfer between Luke and Williams if needed.

Senator GOLDWATER. You can achieve the same thing by simulation?

If you want to put a pilot in the dome at Williams, you can project the enemy fighter?

Colonel ELIASON. Yes, sir, that is correct. We can project enemy fighters or friendly aircraft as well.

We have approximately four different dome capabilities and at this moment we are undergoing an evaluation of which cockpit should be upgraded to newer standards to match the real airplanes that are in service today and how many cockpits we can afford and how many can be shuffled from dome to dome so that we can have truly changeable research.

Senator GOLDWATER. Are you finding the formation simulator valuable?

Colonel ELIASON. We don't use that particular T-38 formation trainer any more because we now have capability in the major dome systems. The dome itself can now do that.

Senator GOLDWATER. I don't know if we have reached this point. This is a rather hypothetical question.

Suppose we went to a 24-hour, 7-day operation. Would you get better utilization of the laboratory?

I will put it another way. Have you reached the point yet where you would even consider that?

Colonel ELIASON. No, sir. We are adequately funded in our support contracts for the amount of operating time that we have.

Senator GOLDWATER. This is for the manufacturing end of it. It appears that computer-generated imagery simulator visual technology has virtually run the gamut of its capabilities, but still does not provide the real world imagery required in tactical visual scenarios.

What new technology is industry pursuing to bridge this gap and what are the expected costs going to be for DOD?

Mr. CHRIST. Senator, I think that the computer-generated imagery in the case of the electronics has gotten to the point where it will meet the tactical training needs. I agree with what Colonel Eliason said as far as the visual display. I believe that is where the R&D efforts have to be focused on in order to get the kind of resolution he talked about in his presentation.

What we are doing is basically working with all the services on the kind of concepts that Colonel Eliason reviewed this morning, working to come up with better light valve projectors, improved helmet mounted displays to be able to achieve higher resolution over a narrow field of view.

One point that needs to be made, though, is that the computer-generated imagery of the image generator, as we call it, is adaptable to any of the different types of displays that Colonel Eliason talked about this morning including the conventional CRT and dome displays.

So, regarding the visual system, image generator portion which generates the kinds of realism we saw in the tape is something that, if it were procured today and utilized on a less than full view system, which is ultimately desired, would still be applicable in the future when the kind of display technologies that we talk about do become available.

Senator GOLDWATER. Mr. Turner?

Mr. TURNER. I feel the same way. I feel the cutting edge is not any longer the implementation of the image generation portion. We have to solve the display problem, do away with heavy helmets, the ability to let the pilot operate in his true visual environment and get that display to him in a realistic fashion.

That is what we are both working on.

Senator GOLDWATER. This is just a general question for my own information.

I can remember when we first got into fighter training simulation, there were two schools of thought: One, that there had to be motion of the aircraft; that is, turbulence, and so forth and so on: the other was just ability to teach the technique.

Have you gone to technique now instead of motion?

Colonel ELIASON. Yes, sir, for the fighter cockpit, we have eliminated the platform motion system. I think it relates to the amount of fidelity that can be produced.

In other words, you can never make the simulator do consecutive 360-degree rolls; you always have to wash it back out. So, we are limited because of the flow of that motion system in how much fidelity we can ultimately achieve.

Our studies at HRL indicate that if you are in a center-line-thrust airplane in a tactial mission with a wide field of view visual system, you get no benefit from the capability of a full moving platform.

There is some benefit from a seat that moves around and some benefit in pilot acceptance with the gravity suit. So, most tactical systems today still carry the gravity suit inflater, some seats, but none of the full motion because it showed no payoff and it was expensive.

Now, we have not put to bed entirely the motion question for wide body aircraft or particularly the B-1. The B-1 will have motion because it appears that there is some value in asymmetrical yaw situations in and out as well as low level turbulence realism in training.

Senator GOLDWATER. Is the B-1 simulator doing a good job on terrain following?

Colonel ELIASON. I am sure it will as it is developed.

Senator GOLDWATER. It has not reached that stage yet?

Colonel ELIASON. No. The B-52 does have that and is working.

Senator GOLDWATER. Colonel, since HRL is the most advanced simulation laboratory for the Department of Defense, what major Army or Navy projects are you now supporting?

Colonel ELIASON. We are supporting the Army's advanced visual component development program which was shown on the screen.

Senator GOLDWATER. Are you doing the H-64 over there?

Colonel ELIASON. No, sir, we do no helicopter work.

Senator GOLDWATER. Do you get into any of the ground simulation like the Abrams tank?

Colonel ELIASON. No, sir. We don't have any of that in our funding plan.

Senator, with reference to the H-64 question, the Army's advanced visual component development program is designated

toward the H-64, but we have no 64 cockpit or no motion for the A-64. We are doing the visual system R&D for the 64.

Senator GOLDWATER. We are trying to get the DOD conference report on the floor at 11 o'clock. So, I have to hurry it up. I don't know whether I can hurry it up or not.

Colonel, do you plan to increase your efforts in determining the training effectiveness of our simulators now on the drawing board such as the simulator for the Army's LHX helicopter?

Colonel ELIASON. Sir?

Senator GOLDWATER. Do you plan to increase your efforts in determining the training effectiveness of our simulators now on the drawing board such as the simulator for the Army's LHX helicopter?

Colonel ELIASON. No, sir, we don't have any plans for LHX work specifically. To the degree that it transfers the work which we have ongoing and projected, it is devoted primarily to the Air Force technical arena and to the degree there is transference, that information certainly is available and will be provided to the Army, but we have no plans for LHX work itself.

Senator GOLDWATER. I want to make part of the record here a very interesting short article that appeared on simulators in Flying magazine of October 1984.

[The article from Flying magazine follows:]

[From Flying magazine, October 1984]

NEW REALISM—SOMEDAY, ALL TRAINING SHOULD BE THIS GOOD

(By Richard L. Collins)

General aviation flight simulation is moving into an important new stage with the advent of Phase II simulators. Because these new simulators have greater freedom of movement (meaning they can better simulate the feel of actual flight) and more sophisticated computers and visual systems, they can be approved for landing credit and, if desired, can virtually substitute for aircraft in the training process.

Flight Safety International is expanding rapidly into Phase II simulation, and has one of the first approved machines at its Savannah, Georgia, Gulfstream training facility. A G-III simulator, it'll convince you that it is not only faithful to the airplane, but also enables you to see and feel things realistically that you'd surely want to avoid in the airplane.

Even taxiing is duplicated in the new simulator. This is important in initial G-III training because it takes a deft touch on the responsive nosewheel steering and the powerful brakes to give the passengers the smooth ride that they expect and deserve.

On takeoff, the roughness of the runway is duplicated, and the simulator makes you feel as if you are accelerating. Traffic on an intersecting runway can be depicted by the visual system. The visual encompasses both front and side windows, and while it still isn't perfect (it's hard from the pilot's seat to see a taxiway to the right, for example) in most operations it's an almost haunting reproduction of how it looks at night.

The control pressures in a Gulfstream are as you'd imagine from the size and heft of the airplane, and the new simulator does an excellent job of duplication. Where, in older simulators, you could almost learn to fly the simulator without being able to fly the airplane (and, as many would insist, vice versa) the new Phase II simulator *is* the airplane.

Engine cuts, systems failures and emergency descents are the ingredients of which simulator training is made. With Phase II, though, the big advance is in the area of airport environment. Thunderstorms that feel all too real can be positioned to harass the airplane as it is flown through an approach and landing. The landing is realistic—a real advance over the old simulators. Severe windshear can be duplicated (I think they have all the infamous windshear accident scenarios in there) and flown. This adds an important element to simulation. In addition to making pilots

cope with all the things that can go wrong with the airplane, they can now add weather—and most pilots agree that the weather misbehaves more often than the airplane in actual flying.

Flying an ILS in the bowels of a thunderstorm is an interesting exercise. In one of the scenarios, the airplane is affected by the updraft as it flies from the outer marker toward the airport. Even with the power at flight idle, the big G–III trends high on the glideslope, and the speed stays a little high as you lurch through the turbulence. Even knowing what is going to happen next doesn't fully prepare you for the horrendous sinking spell that occurs at about the time the approach lights become visible—off to the right because of more drift correction than you might think would ever be required in a G–III. If the power is advanced at the first sign of sink, the nose is pitched up to where the stick shaker (stall warning) activates, and if the airplane is properly cleaned up, it will fly out of the sink without hitting the ground. But it's close, very close, and requires a fine touch. Then, of course, once you get it going it's back into the updraft and turbulence. A few weeks after I flew the G–III simulator, a DC–9 did a belly flop on a runway during a thunderstorm; I could appreciate the pilot's feelings.

Whenever I fly one of Flight Safety's machines and am exposed to the training available to people operating turbine airplanes, I come away wishing for a better training system for everyone. There is so much there, and better training could do so much for the safety record. We'll never have it all—you could never afford a Phase II simulator for a Bonanza or Baron, for example, but maybe someday we'll have high-quality initial and recurrent training for all airplanes.

CRUSADING

Every now and again an airplane has to take a little time off for refurbishment. In early summer, mine was in the shop for a major overhaul of the engine. I leased a Cessna T303 Crusader twin.

On the checkout, we did the obligatory single-engine flying and found that it does just about what the pilot's operating handbook says it will do. That's not much in some cases: the book showed that for our altitude (4,000 feet) and conditions (hot), about 75 fpm is the maximum available single-engine rate of climb. But the airplane handles nicely on one engine and, given reasonable pilot proficiency, it could get you to a runway after an engine failure unless the failure occurred in the early part of the initial climb. There you'd probably want to take advantage of the Crusader's low stalling speed while landing in the nearest pasture.

The fit and finish of the airplane were impressive, as was the work Cessna has done to quiet and smooth the ride. With a few exceptions, the Crusader exudes quality workmanship. The ride is nice, and even at full-power climb (particularly desirable in the summer, for cruise-climb doesn't do much) it's not noisy.

The cruise capability at 140 pounds per hour total fuel flow is 165 knots. I've heard that some people shove the power in and go faster (140 pph translates to top-of-the-green on manifold pressure and 100 rpm below top-of-the-green on rpm) but the fuel flows would go up correspondingly. You have to balance fuel and cabin load, so there might not be a lot of trips where it would be possible to pour through extra fuel for a few knots. The airplane I used was moderately equipped (it had everything, really, but air conditioning) and when I totaled three plus a little baggage, we had to leave out 120 pounds of fuel. That made the three-hour legs work out with comfortable fuel reserves—we could have gone well into the third hour and still have had the one-hour reserve that is my policy.

The cabin of the airplane looks, and is, big. Club seats in the back and an airstair door put it in the big league. The trip from the entrance to the front takes finesse. If I had a Crusader I'd remove one of the cabin seats to make moving around easier and to add a little to available payload. Flying with six aboard would be limited to very short trips and would not be done often because of weight limitation. Like many other airplanes, the Crusader flies with too much furniture.

Most of the trips flown were affected by thunderstorm activity at one point or another and the Bendix color radar did a fine job of suggesting alternate routes. When it gets bumpy, the Crusader rides well; the yaw damper helps.

Perhaps the nicest item of all is the Crusader's flight deck, once you get settled. The number of circuit breakers on the left panel attests to the dual nature of the electrical system. The panel is well laid out and looks just right. Visibility is excellent. The handling qualities are as fine as they come. From the pilot's standpoint it is a very satisfying airplane to fly. There is a problem with ground operation of the engines in hot weather—they tend to stumble and even stop running at idle power—and in flight at high outside air temperatures the fuel-flow-reading pressure

gauges fluctuate even with the aux pumps on. The engines are very tightly cowled and have internal cowl flaps that seem effective at managing cylinder head and oil temperature, but apparently they let the fuel lines get awfully hot.

One strong impression of the Crusader is of size. It's a big airplane. And while its 250-hp engines don't make it into a rocket ship, they combine with the airframe to give a serene ride.

Senator GOLDWATER. I want to thank you gentlemen for coming. I think the industry demonstration has been very, very well done. Naturally, I am prejudiced, I think the Air Force did a good job, General; and Colonel, I will be over there to see you and I will be around to see you fellows at your factories.

[The statement of Robert E. Gordon follows:]

PREPARED STATEMENT BY ROBERT E. GORDON, PRESIDENT, AMERICAN AIRLINES TRAINING CORP.

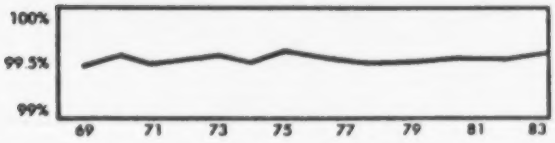
CONTRACTOR AIRCREW TRAINING

Mr. Chairman, and Members of the Subcommittee, I am Robert E. Gordon, President of American Airlines Training Corporation. I am pleased to have the opportunity to discuss the role of contractor training for the Department of Defense.

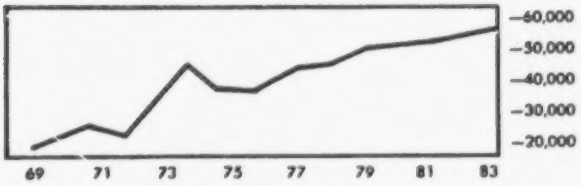
You have heard from the DoD and the other industry representatives about the increasing complexity and cost of modern machines and systems. Those conditions, along with the ever present need to maintain a strong and highly trained war fighting force, have created a growing demand for advanced training concepts.

In the recent history of simulator procurement, we have witnessed the distressing phenomenon of the DoD having to pay almost as much for a simulator as they pay for the aircraft being replicated. We at American Airlines understand the DoD plight because twenty years ago we found ourselves in the position of having to revitalize and to restructure our own training program, and we had to do it in such a way that our operating costs would be reduced, our training would be completely standardized, and above all, the safety of our crews and passengers could be assured. We discovered that all this could be accomplished by adopting and using a total training concept which includes heavy utilization of flight simulation.

QUALITY TRAINING
Depends on Well-Maintained Equipment



Actual Simulator Availability Rate



Simulator Utilization Rate
in Hours*

*Tables Reflect 16 Hours Day/363 Days per Year of Operations

Slide (1) will show you how much American Airlines has used flight simulators over the last decade. Another important point to note from this slide is the availability of our simulators during the same period. A highly skilled and stable support and maintenance force is an absolutely essential ingredient of the total training package.

The safety record which we now enjoy is, in large part, attributable to the total training concept that has been instituted at American Airlines. Although we believe in the use of flight simulators, we have learned that no matter how closely a simulator replicates the real world and no matter how much technology is available, the final training result ultimately will be directly dependent upon how the existing hardware and technology are applied and utilized. It is this training concept that I wish to discuss today. Commercial contractor training is probably not the answer to all aircrew training. There are certain highly specialized training missions which ought to be taught by the military's own. However, there are training requirements which could be better met, from the standpoint of more effective resource utilization, by a contractor. The Air Force's existing KC-10 training program is the model which I shall use to describe what we mean by contractor training.

The Air Force, leading the way in utilizing commercial training, contracted with American Airlines for trained KC-10 crewmembers. It was American's responsibility to define the hardware, courseware, facility requirements, contractor personnel and procedures necessary for the operation, support and maintenance of a Total Training System. The USAF objectives in the KC-10A training system are shown in Slide (2).

USAF OBJECTIVES IN KC-10A TRAINING SYSTEM

- UTILIZE COMMERCIAL TRAINING PROCESS
  - TRAINING TECHNOLOGY AND SYSTEM DEVELOPMENT
  - COMMERCIAL CONTRACTING
  - SHORTEN TIME TO RFT DATE
- LOWER OVERALL TRAINING COSTS
  - REDUCE FLYING HOURS FOR TRAINING
  - REDUCE SYSTEM PROCUREMENT & OPERATING COST
- MINIMIZE UTILIZATION OF KEY USAF PERSONNEL
  - FREE AF INSTRUCTORS FOR MISSION FLYING
  - REDUCE NEED FOR AIR FORCE MAINTENANCE PERSONNEL
- BUY CAPABILITY FROM ONE CONTRACTOR WHO
  - HAS SUCCESSFULLY DEVELOPED TRAINING SYSTEMS
  - ASSURES ALL SYSTEM ELEMENTS ARE INTEGRATED

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It should be noted that Commercial Contracting under the first bullet refers to the fact that all of the hardware necessary to support the training program was specified and procured by American Airlines using best commercial practices. As a point of interest, the 6 Degree of Freedom mission simulator was procured from Singer-Link, who addressed you earlier today.

USAF RESPONSIBILITIES

DEVELOPMENT PHASE

- ESTABLISH THE TRAINING REQUIREMENTS (51-SERIES AND 55-SERIES REGULATION)
- DEFINE PERFORMANCE CRITERIA (60-SERIES REGS, STAN/EVAL)
- PROVIDE A TEAM OF SUBJECT MATTER EXPERTS (SMEs)

OPERATIONAL PHASE

- PROVIDE FLIGHT INSTRUCTORS
- PROVIDE FLIGHT EXAMINERS
- ONGOING OPERATIONAL FEEDBACK TO CONTRACTOR (CURRICULUM REVIEW BOARD, STUDENT CRITERIA, OPERATIONAL EVALUATION, ETC.)

As shown in Slide (3), the Air Force did not abrogate responsibility for the program. On the contrary, the Air Force had the significant task during the development phase of defining their training requirements. American was willing to guarantee trained crewmembers, but to do that, there had to be agreement about the requirements and how these requirements would be evaluated. The Air Force provided a team of Subject Matter Experts for the KC-10A crew positions. This insured communication and agreement between American and the Air Force during the development processes.

It is important to note also, from Slide (3), that the Air Force provides all flight instructors and flight examiners required for the training program. American's responsibility is for all aircrew ground training in preparation for actual aircraft flight. It is the Air Force which provides the inflight training to the student and examines the trainee to determine if he or she meets qualification requirements. There is a "no disputes" clause in this contract regarding the evaluation of proficiency by the Air Force.

AMERICAN AIRLINES CONTRACT RESPONSIBILITIES

- ANALYZE KC-10 TRAINING NEEDS
- DESIGN KC-10 TRAINING SYSTEM
- DEVELOP TRAINING HARDWARE & COURSEWARE
- INSTALL SYSTEM AT BARKSDALE AFB
- TRAIN AIR FORCE CREWS TO FULL MISSION QUALIFICATIONS

The contractor's basic responsibilities, which were discussed earlier, are shown on Slide (4). The first KC-10 school house has been installed at Barksdale AFB and has been in operation for nearly three years. The Air Force has contracted with American to install duplicate training centers at March AFB and at Seymour-Johnson AFB.

MAJOR CONCERN

CAN SAC LOSE CONTROL OF ITS TRAINING FOR KC-10A AIRCREW IF A CONTRACTOR IS INVOLVED?

NO

- KC-10 AIRCREW ARE TRAINED TO MISSION QUALIFICATION CRITERIA
- AIR FORCE FLIGHT EXAMINERS CERTIFY AIRCREW QUALIFICATIONS IAW 60-4
- SAC DEFINES WHAT RESULTS IT WANTS
- AMERICAN WARRANTS ITS PRODUCT TO SAC
- SAC PARTICIPATES IN CURRICULUM REVIEW BOARDS, COURSE UPDATES, REVISIONS, ETC.

In the early stages of development of the KC-10 program, the Strategic Air Command had a concern about whether the Air Force would lose control of the training program if a contractor were involved. As you can see from Slide (5), the Air Force does not lose control and, in fact, SAC has found that they actually have more control since it is they who determine the acceptability of the training. In addition, the Air Force has a single accountable contractor for any surfaced issues and concerns.

RISKS

- TRADITIONAL AIR FORCE PROCUREMENT
  - SCHEDULE
  - COST
  - PERFORMANCE/SYSTEM INTEGRATION
- COMMERCIAL PROCUREMENT
  - SAC ACCEPTANCE OF A COMMERCIAL APPROACH
  - SELECTION OF AN INEXPERIENCED CONTRACTOR

There are some risks in the procurement of a training system. On Slide (6), we see that the traditional procurement route has had problems with schedules and with costs. That, we believe, is a result of the way the government procures hardware. Inordinately complex specification and testing requirements makes it virtually impossible for a contractor to provide a cost effective piece of equipment on schedule especially compared to the commercial approach. This Subcommittee will be pleased to know, as we were, that the DoD is in the process of revising their regulations and policies to provide more flexibility and innovation in contracting for training systems. General Marsh, former Commander of the Air Force Systems Command, stated on 14 November 1983 that, "-- the final product is not hardware. Your final product is a fully trained man or woman." This signals a departure from training hardware procurement to a system for a trained product.

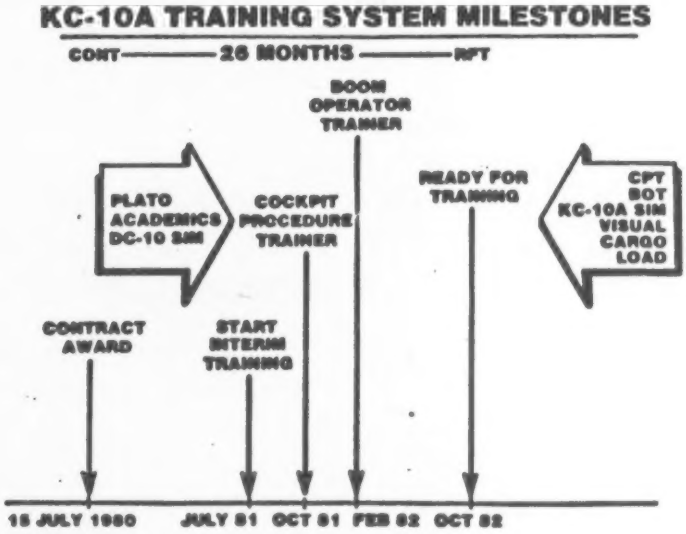
As further depicted on Slide (6), we believe the biggest risk in a commercial system is the danger of selecting a contractor who lacks experience in government contracting, training in large or high performance military aircraft, or in training the military missions.

KC-10A AIRCREW TRAINING PROGRAM

- ACADEMICS
  - COMPUTER AIDED INSTRUCTION
  - AUDIO VISUAL TUTORIALS
- COCKPIT PROCEDURE TRAINER
- BOOM OPERATOR TRAINER
- CARGO LOADING TRAINER
- OPERATIONAL FLIGHT SIMULATOR (BUILT TO FAR-121)
- TRAIN TO SACR 60-4 QUALIFIED LEVEL

The next slide, Slide (7), summarizes what comprises the KC-10A training programs. The programs include an academic portion which, for the most part is largely automated and self-paced. That is, although each phase of academic training has a beginning and ending, the program has the flexibility of allowing a student to progress faster or to receive additional instruction as required. You should note that the Operational Flight Simulator was built to FAA FAR-121 standards and is a 6 degree-of-freedom simulator with a full day/night visual and with the capability of training air-to-air refueling. The proficiency level required by each SAC crew member, and guaranteed by American Airlines, is the SACR 60-4 Qualified level.

How does the military evaluate the proficiency level which has been guaranteed by the contractor? The Air Force evaluators administer Standardization/Evaluation checks of the students after the contractor has determined that the student is ready to be tested. Since the contractor is obligated to re-train, at no cost to the government, any student who fails the Air Force administered evaluations, American does not recommend a student for testing unless it is satisfied that the crewmember has been fully trained. This is done through numerous contractor administered tests and checks during the training course.



As I mentioned earlier, one of the traditional problems that the military has in simulator procurement is the schedule. Slide (8) shows the KC-10A training system milestones. As you can see, American started interim training of KC-10 crews one year after contract award utilizing one of its own DC-10 simula-

tors. But the important point to note on this slide is that the total system, including all hardware and academics, was ready for training 26 months after contract award.

BENEFITS TO AIR FORCE OF AMERICAN'S TRAINING SYSTEM

- TRAINING EQUIPMENT STAYS CURRENT WITH ACFT CONFIGURATION
- COST OF TRAINING IS MEASURABLE AND PREDICTABLE
- EQUIPMENT IS RELIABLE
- TRAINING SYSTEM STAYS INTEGRATED
- HISTORICAL EXPERTISE IS MAINTAINED
- RELIABLE AND STANDARDIZED RESULTS
- CONTRACTUAL ACCOUNTABILITY
- RESULTS GUARANTEED TO USAF CRITERIA

The next slide, Slide (9), shows the benefits being derived by the Air Force from this KC-10A Total Training System. Two points in particular are worth highlighting.

(1) The cost of training is measurable and predictable.

(2) Historical expertise is provided. The KC-10A contractor instructors have a combined military experience totaling over 400 years. Rather than being a lost resource, this military experience and expertise is retained through retired personnel. Instruction becomes a career rather than just being one facet of the career of a military member.

KC-10 TRAINING RESULTS
for FY81, FY82, FY83

TYPE CLASS	# OF CLASSES	P	CP	FE	BO	TOTAL	SUCCESS RATE
Initial Qual	29	53	59	56	60	228	98%
Senior Staff	3	3				3	100%
Pilot Upgrade	9	18				18	100%
Inst Upgrade	16	29		31	33	83	100%
Sim Ref	169	207	118	161		486	100%
Init Cadre (Sim Ref)	5	8	2	5		15	100%
CPT Ref	81	77	58	77		212	100%
BOT Ref	260				260	260	100%
	572	395	237	330	353	1305	99.7%

The results of the KC-10A contractor training program are shown in Slide (10). This reflects the result of first flight checks. In all cases except one, the failed member succeeded in a subsequent check. With three years of training now behind us, the Air Force is enjoying the results of a cost effective and completely successful training program. It is significant that the Air Force had this to say about the cost of the KC-10A program: "We contracted with American Airlines to train our KC-10 crews. For twenty years, the contract will cost $134 million instead of $277 million if we did it ourselves -- (AF/RDCA)".

AMERICAN'S TRAINING PHILOSOPHY

- SYSTEMATIC INSTRUCTIONAL DEVELOPMENT
- BUILDING BLOCK APPROACH
- HANDS ON TRAINING
- INDIVIDUALIZED INSTRUCTION
- TRAINED TO GUARANTEED PROFICIENCY

Finally , to summarize, we are pleased to be a part of the DoD procurement process and to be partners in the business of training a highly skilled war fighting force. Our business and training philosophy is simple and straightforward as seen in Slide (11). The commercial approach to training is working for the KC-10 program. It will also work for the Air Force E-3 program which was recently contracted to another company. In addition, the Air Force plans to award a contract for the C-5 training within the next month. We have heard that the Navy may contract for a commercially operated training program for the E-6 system. We believe that this is the way of the future in providing the DoD with cost effective and quality training for our fighting forces. The end product of a "total systems" approach to training is a student trained to user-defined standards of proficiency.

Thank you again, Mr. Chairman, for the opportunity to acquaint the Subcommittee with the concept of contractor aircrew training in military programs.

[Questions with answers supplied follow:]

QUESTIONS SUBMITTED BY SENATOR BARRY GOLDWATER

TECH REPORTS PUBLISHED BY AFHRL

Senator GOLDWATER. Would you please submit for the record a list of Technical Reports published by the HRL over the past two years on the subject of training effectiveness of simulators and part-task training devices?

ANSWER:

(1) NAVTRAEQUIPCEN 78-C-0060-9/AFHRL-TR-82-3, Applications of Simulator Freeze to Carrier Glideslope Tracking Instruction, July 1982.
(2) AFHRL-TP-82-5, Color Television Projection System Using Three Cathode Ray Tubes, March 1982.
(3) NAVTRAEQUIPCEN IH 343/AFHRL-TR-82-15, Air Combat Maneuvering Performance Measurement State Space Analysis, October 1982.
(4) AFHRL-TP-82-28, Spatial Orientation and Motion Cue Environment Study in the Total In-Flight Simulator, June 1983.
(5) AFHRL-TP-82-34, Visual Scene Simulation Requirements for C-5A/C-141B Aerial Refueling Part-Task Trainer, May 1983.
(6) AFHRL-TR-82-39, Air Combat Simulation Visual Display Requirements: An Application of Engagement Simulation Modeling, March 1983. (Limited Distribution)
(7) AFHRL-TP-82-42, Derivative Fighter Training Consideration, March 1983. (Limited Distribution)
(8) AFHRL-TP-82-43, Low Altitude Training: A-10 Aircraft, June 1983.
(9) AFHRL-TP-83-6, Temporal Aspects of Eye Movement When Viewing Multiple Targets, November 1983.
(10) AFHRL-TR-83-8, Effects of Transport Delay on Simulator Air-to-Air Engagements, September 1983.
(11) AFHRL-TR-83-17, Low-Level Flight Simulation: Vertical Cues, September 1983.
(12) AFHRL-TR-83-21, Surface-Attack Mission Simulation: Preliminary Scenario Evaluation, November 1983.
(13) AFHRL-TR-83-22, Aircrew Training Devices: Utility and Utilization of Advanced Instructional Features (Phase I—Tactical Air Command), November 1983.
(14) AFHRL-TP-83-24, Flying Training R&D at the Air Force Human Resources Laboratory, June 1983.
(15) AFHRL-TR-83-27, Flight Simulator: Improved Performance Silicon Light Valve, March 1984. (Limited Distribution)
(16) AFHRL-TP-83-36, Application of Air Combat Maneuvering Instrumentation (ACMI) Data for Performance Measurement, September 1984. (Limited Distribution)
(17) AFHRL-TP-83-37, Real Visual Image Compensation for Head Motion Parallax Effects as a Function of Object Distance, September 1983.
(18) AFHRL-TP-83-38, Instruction Station Display for Use in T-37 Flight Simulation Training, October 1983.
(19) AFHRL-TP-83-39, Nuclear Warfare Engagements on F-16 Flight Simulator—Feasibility Demonstration of Software, November 1983. (Limited Distribution)
(20) AFHRL-TP-83-45, Nonlinear Prediction of Head Movements for Helmet-Mounted Displays, December 1983.
(21) AFHRL-TP-83-46, Aircraft Simulator: Multiple-Cockpit Combat Mission Trainer Network, January 1984.
(22) AFHRL-TP-83-53, Flight Simulator Study to Estimate the Impact of a Directed Energy Threat Upon the A-10 Close Air Support Mission (U), March 1984. SECRET.
(23) AFHRL-TP-83-56, Air Combat Maneuvering Performance Measurement System Design, March 1984. (Limited Distribution).
(24) AFHRL-TR-84-13, Airborne Performance Measurement System Design: C-5 Aircraft, August 1984.
(25) AFHRL-TR-84-22, Comparison of Color Versus Black-and-White Visual Displays as Indicated by Bombing and Landing Performance in the 2B35 TA-4J Flight Simulator, July 1984.
(26) AFHRL-TP-84-32, Practice Makes Perfect, October 1984.

STUDIES AT AFHRL

Senator GOLDWATER. What formal studies are now being conducted at HRL in flying training effectiveness of training systems (hardware, software, and courseware) to support the Air Force Simulator SPO?

ANSWER. The Air Force Human Resources Laboratory has developed a long-range training effectiveness research and development program in support of the Simulator SPO. This program will determine the minimum levels of fidelity or realism required for a flight simulator to provide effective training. The eight research and development issues being addressed are: Training System Design, Visual Scene Fidelity, Sensor Scene Fidelity, Instructor Operator Station Design Requirements, Aircrew Performance Measurement, Cost-Training Effectiveness Relationships, Simulator Instructional Strategies, and Force Cueing System Fidelity. Specific plans for these studies have been briefed to the Commander of the Air Force Systems Command, who has approved their initiation; the Simulator SPO has coordinated on the plans.

AFHRL is also developing a Low Altitude Navigation Terrain-Following Infrared Night (Lantirn) simulation capability to support some of these training effectiveness studies, and will collect pilot performance data to assist the Simulator SPO in developing design specifications for the operational Lantirn simulator.

TRAINING RESEARCH SUPPORT BY AFHRL

Senator GOLDWATER. How does HRL plan to provide training research support to the Air Force Nighthawk HH-60 program?

ANSWER. There is no HRL support currently planned to support the HH-60 program.

Senator GOLDWATER. I guess that is it. We stand adjourned.

[Whereupon, at 10:50 a.m., the subcommittee adjourned, subject to the call of the Chair.]

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